Sky and TELESCOPE

Cosmic ray balloons

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Star Chains

The Story of Cosmic Rays — III

American Astronomers Report

The Sky at Totality

Filming the Total Eclipse

Northern and Southern Star Charts

Vol. XIII, No. 6

APRIL, 1954

5-INCH FECKER-ROSS ASTROGRAPH

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Sky and TELESCOPE

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THE ORIGIN AND AGE OF METEORITES

AT a symposium on meteorites, held in Boston in December by the American Association for the Advancement of Science, some 20 papers were presented. More than anything else, these brought out the uncertainties, and even reversals of opinion, in the minds of many authorities on the origin and age of meteorites. One speaker, scheduled to talk on "The Shattered Planet Hypothesis of the Origin of Meteorites," stated that he no longer was certain of that theory, and instead spoke on a directly observed characteristic of museum specimens: the uniformity of composition of the silicate phase in chondrites. Among the many samples they studied, Dr. William Pinson and his co-workers at the Massachusetts Institute of Technology found such a marked consistency from meteorite to meteorite in the abundance of the elements lithium, potassium, rubidium, scandium, strontium, barium, and zirconium, that he believes all specimens had a common origin in time and space.

Similar conclusions as to the uniformity of the chondrites were reported by Walter Wahl, of Helsinki, Finland, who also noted that they had undergone pressure and heat changes since their formation. Dr. Wahl believes that they are all fragments of the same body.

Widespread interest in such questions is reflected not only by the symposium papers but by many publications in recent months. For example, C. de Jager, at the Sonnenborgh Observatory at Utrecht, Holland, has studied the spherical chondrules in chondrites and the triolite globules in iron meteorites. Their shapes indicate that neither could have been exposed to high pressure during solidification: the surface tension of the liquid droplets was able to withstand the pressure of the overlying layers. From this he concluded that the celestial body of which the meteorites were formed was 0.5 to one kilometer in diameter.

At the symposium, Prof. F. Paneth, of Durham, England, was concerned with the age of iron meteorites, especially as determined from their helium content. As Carl Bauer pointed out some years ago, the helium in meteorites is produced not only by radioactivity but also by cosmic rays. Professor Paneth was able to prove the correctness of this by measuring the abundance of the rare helium isotope of atomic weight 3, finding it relatively much more abundant in meteoritic helium than in terrestrial helium.

From the amount of He^3 in a meteorite, Professor Paneth could tell what fraction of ordinary helium (He^4) was formed by cosmic rays; the remainder of the He^4, being of radioactive origin, could be the basis of an age calculation. Results for a dozen iron meteorites show them much younger than the solar system: some appear to have solidified less than a million years ago, while the majority are about as old as terrestrial mesozoic rocks.

Lively controversy was incited by Dr. Harold Urey's closing address, "The Origin of Meteorites." The University of Chicago chemist regards them as debris from the collision of two large asteroidal bodies. Such bodies, on his theory, would have been formed in the sun's vicinity some four and a half billion years ago from material collecting together at low temperatures. He then postulates that the asteroidal bodies began to heat from the surface inward by some unexplained mechanism. If the temperature reached the melting point of iron, the observed physical characteristics of meteorites would then be accounted for. To break up such a body into meteoritic fragments, collision with another body of comparable size would be needed.

Dr. Harrison Brown, University of Chicago, in his summarizing remarks, pointed out that the two most pressing problems in meteoritics are age determinations and accurate studies of how the chemical elements are distributed in meteorites of all types. He stressed particularly the importance of using uncontaminated specimens for such fundamental work—a precaution too often neglected.

D. H.

VOL. XIII, NO. 6 APRIL, 1954

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COVER: On the shores of Hudson Bay, near Ft. Churchill, Canada, in the early morning hours during the summer of 1949, cosmic ray scientists regularly released strings of balloons to carry their recording apparatus as high as 20 miles into the upper atmosphere. Because of its high geomagnetic latitude, the Ft. Churchill site was chosen for a joint project of the National Geographic Society and the Bartol Research Foundation of the Franklin Institute. (See page 185.)

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FEATURE PICTURE: The Milky Way in Cygnus and Cepheus, photographed by Frank E. Ross at Flagstaff, Ariz., October 14, 1930, with a 5-inch, f/7 Ross-Fecker camera, exposure time three hours. It is reproduced from Plate 18 of the Ross-Calvert "Atlas of the Northern Milky Way," University of Chicago Press 180

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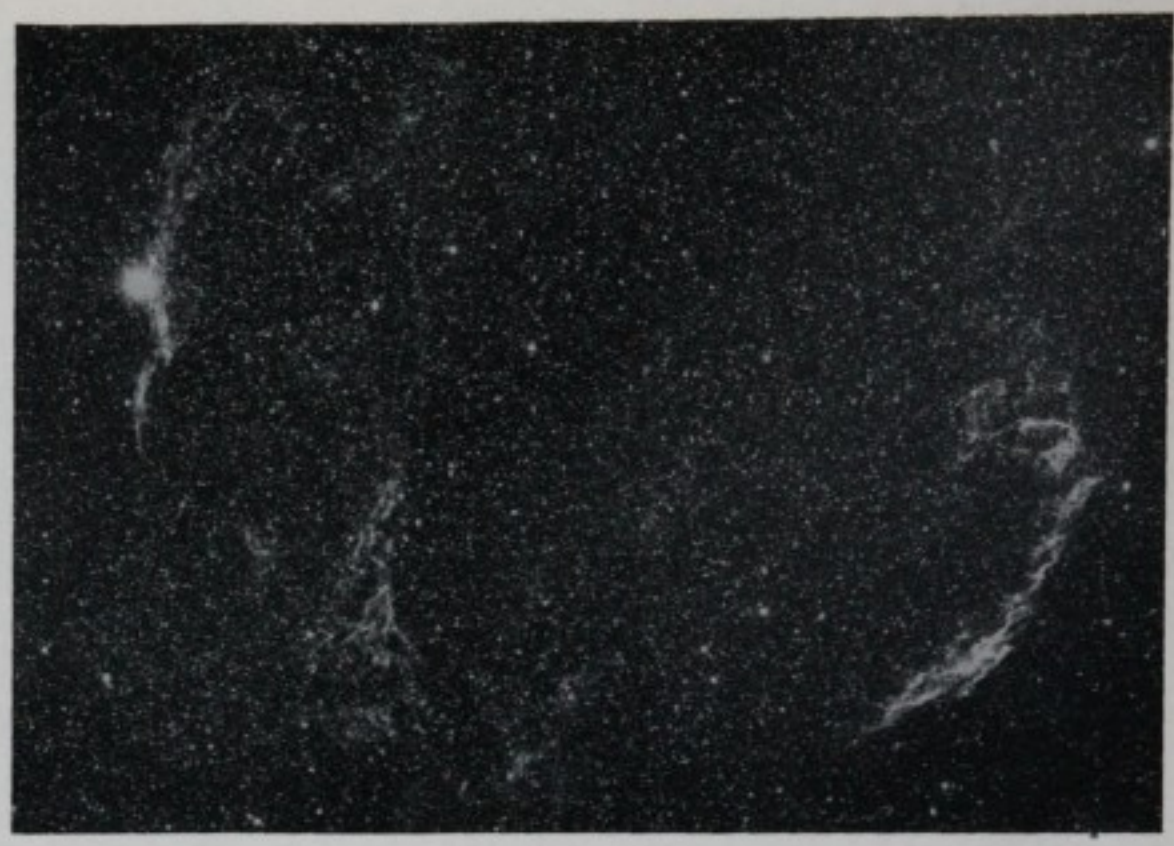


Fig. 1. The Veil nebula in Cygnus, photographed with the Harvard 24-33-inch Schmidt telescope. South is at the top. NGC 6960 is the nebulosity attached to the very bright star at the left; NGC 6992 is the bright elongated nebula in the lower right corner, and NGC 6995 is the smaller detached mass just above it. The regions covered by Figs. 2 to 5, where Fessenkov indicates star chains, can be identified from this key chart; measure in inches from the upper right corner leftward and downward, respectively, for Fig. 2, 3¼, 2½; Fig. 3, ¾, 2½; Fig. 4, ½, 2¼; Fig. 5, 4¼, 1½.

STAR CHAINS

By Otto Struve, *Leuschner Observatory*
University of California

ON THE PHOTOGRAPH of the Milky Way facing this page, the North America nebula is a conspicuous feature (in the lower right). Of more immediate concern to us now are certain lines of stars above it, easily located with the aid of a ruler.

Measure to a point about four inches from the bottom and 3¼ inches from the inside (right) edge of the picture; then find a second point six inches from the bottom and two inches from the inside edge. Place your eye near the middle of the lower edge of the photograph and sight along the straight line formed by the two points you have just measured.

You will notice that the stars along this line form a remarkably conspicuous chain in which a few relatively bright stars are followed by groups of three or four fainter ones, all of approximately the same brightness and at about equal distances from one another.

Next, shift your attention about 1¾ inches to the left and you will find another string of stars roughly parallel to the first, but less conspicuous. Then, about one inch to the right of the first line, there is still another string of stars parallel to these, but consisting mostly of very faint objects.

I doubt that the second and third of these parallel strings of stars would have been discovered if it were not for the middle one, which is really quite striking. I do not know whether this chain has been previously reported in astronomical literature. It is found in other photographs of the region, such as on Plate 48 of E. E. Barnard's *Photographic Atlas of Selected Regions of the Milky Way*, published in 1927. There the first star chain is clearly visible, though it no longer appears quite as straight as it does upon the small-scale photograph by Ross.

Our attention was directed to these star chains by a reader of this magazine, Sidney O. Kastner, of the physics department of Syracuse University. As he states, "It is obvious that this lining-up could not have occurred by chance alone." He believes that these star chains might indicate that stars condense out of gaseous filaments which may or may not have a relation to the spiral arms of the Milky Way.

The problem of star chains is not a new one. However, most previous investigators have been concerned with real or imagined configurations of stars within the dense star clouds of the Milky Way. They have not primarily been interested in nebulous regions or in the possibility of stars condensing out of gaseous filaments.

In a recent study by J. Meurer at the Bonn Observatory, an effort was made to determine from a statistical point of view whether the tendency of an observer to recognize a chain of stars can be explained in terms of purely accidental groupings. Artificial star fields were photographed, the starlike images being produced by scattering dust particles or pollen upon a glass plate. The distribution of the particles was then studied in the same manner as that used by astronomers to study the distribution of star images.

Dr. Meurer concluded that in the Milky Way, on the whole, the stellar distribution does not noticeably differ from the random distribution of the dust or pollen particles. While this conclusion undoubtedly relegates to the domain of psychology the numerous discoveries of star chains in the Milky Way star-clouds, it is still entirely possible that relatively young stars might have originated in filamentary nebulae and might for a comparatively short time retain the aspect of star chains.

On the theoretical side, the problem of evolution of stars from filaments was made attractive by K. E. Edgeworth, who, in 1946, published a series of papers in the *Monthly Notices* of the Royal Astronomical Society. He presented some of his calculations in popular form in articles in *Sky and Telescope* for August and September, 1948. Let us review those portions of his discussion that bear upon our present problem.

Edgeworth attempted to outline what might happen to a gaseous galaxy, consisting almost entirely of hydrogen, beginning with a density of approximately 10^{-24} gram per cubic centimeter. If this gaseous galaxy were rotating around its center in the manner in which the Milky Way is now rotating, its shape would be a thin disk with a thickness of approximately one eighth its diameter. If the internal mass distribution were similar to that of the Milky Way, a tube with one square centimeter cross-section between the top and bottom surfaces of the disk would contain about 1/20 of a gram of material, at a distance of 10,000 parsecs from the center. This is the actual situation at the sun's distance from the galactic center today; in

FACING PICTURE: This region of the Milky Way includes the North America nebula, in the lower right, and parts of the constellations of Cygnus and Cepheus. The overexposed image of Deneb is on the lower right edge. Certain parallel lines of stars are of special interest in connection with the accompanying article. Yerkes Observatory photograph.

other words, if all the material in the Milky Way were flattened out on the galactic plane, in our vicinity it would weigh about as much per unit area as a piece of cardboard, despite the fact that the total mass of the galaxy is more than 10^{11} solar masses!

With the lapse of time, the rotating nebula would contract at right angles to the plane of the disk, but not within the plane itself since this is prevented by the rotation. This contraction would come to an end when the increasing internal pressure became equal to the force of gravity at right angles to the plane of the disk. The resulting ratio of thickness of the galaxy to its diameter would depend on the value assumed for the temperature of the medium. For 100° absolute, the ratio would be about 1/10,000; for 1,000°, about 1/1,000; and for 10,000°, about 1/100. Edgeworth estimated that the temperature of the mixture might be about 100°, but in order not to exaggerate the effect of a low temperature, he adopted a value of 1,000°. This would result, of course, in a far more pronounced degree of flattening than is now observed in the Milky Way as a whole.

The density of the nebula would have increased to about 10^{-21} gram per cubic centimeter. What will happen at this point? Edgeworth introduced Jeans' criterion of gravitational instability, finding that the size of an initial condensation in the cloud is approximately equal to the thickness of the disk, or about 20 parsecs in the above example. The resulting condensations would have masses of about 60,000 suns when the temperature is 1,000°. In order to obtain by direct condensation a total mass of one sun, the temperature would have to be of the order of three degrees above absolute zero, which is inconsistent with the above assumptions for a disk of gas and dust. Only a medium consisting entirely of dust particles could maintain such a low temperature.

While this difficulty does not appear to be very serious, on the basis of the very large initial mass of a condensation and on angular momentum considerations Edgeworth rejected both direct condensation into stars and the formation of stars by successive condensations. He turned to the idea that a rotating disk of gas, when it had become unstable as a result of the inequalities in density bound to form in a thin sheet, would break up into a "number of long parallel filaments." The formation of filaments would avoid angular momentum problems associated with the condensation of flattened spheres and rings.

Therefore, Edgeworth concluded that condensations in a primordial galaxy do not shrink to individual stars, but that the gas and dust breaks up into filaments and fragments of filaments, from which stars are formed. Double and multiple stars might also be expected, in the proper relative numbers, but the main structure of a filament would disintegrate during two or three revolutions of the galaxy.

Apparently the work of Edgeworth went unnoticed by most astronomers despite its highly stimulating nature. It is, therefore, of particular interest to review the observations by V. G. Fessenkov, who has attempted to show that various filamentary nebulosities in the Milky Way are associated with star chains. At the high-altitude observatory in Alma Ata, in Central Asia, he used a meniscus-type reflector designed by D. D. Maksutov. This has a primary mirror of 67 centimeters diameter, and a meniscus correcting lens 50 centimeters in aperture. The equivalent focal length is 120 centimeters and the effective focal ratio is 2.4. Plates of 10 x 10 centimeters cover approximately 25 square degrees. The field is made entirely plane by means of an auxiliary lens. Except in poor seeing, the star images are said to be not larger than 0.02 millimeter.

With the help of red-sensitive plates, some of which were said to be Eastman 103-E emulsion, Fessenkov and his associate, D. A. Rojkovsky, have obtained a large number of photographs of different regions of the sky. They have devoted most of their attention to the Network or Veil nebula in Cygnus, NGC 6960, 6992, and 6995. The photograph on page 181 shows the regions in which they have found groupings of stars that

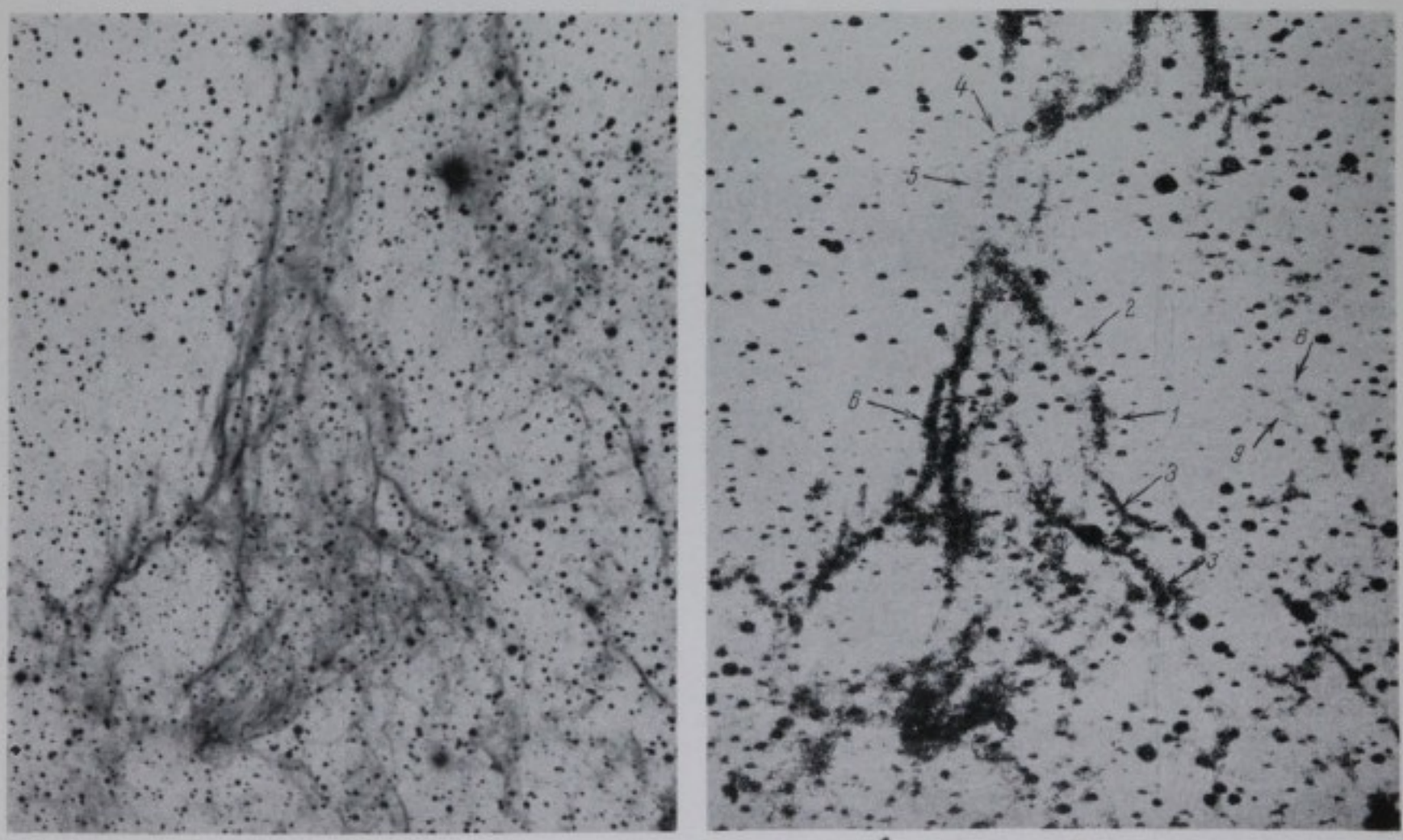


Fig. 2. Comparison can be made here of two negative prints of part of the unnamed nebulosity between NGC 6960 and 6992. At the left, the region was photographed by N. U. Mayall with the 36-inch Crossley reflector of Lick Observatory. At the right, on a picture made at Alma Ata Observatory, Fessenkov and Rojkovsky have marked nine regions they believe contain star chains or stars forming along filaments of the nebulosity.

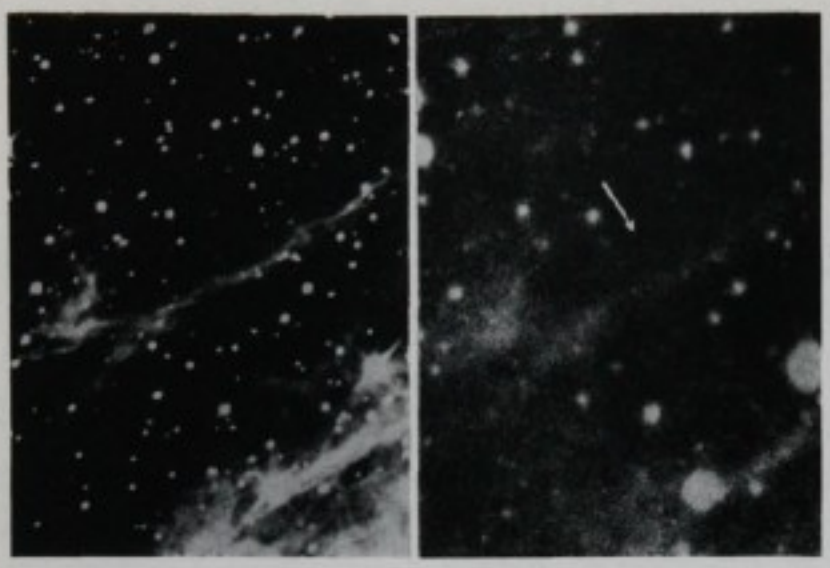


Fig. 3. The arrow points to what Fessenkov calls a chain of 19th-magnitude stars, on a one-hour Alma Ata picture of a small portion of NGC 6992. At the left, on a 60-inch Mount Wilson photograph by John C. Duncan, the feature appears as an irregular wisp of nebulosity.

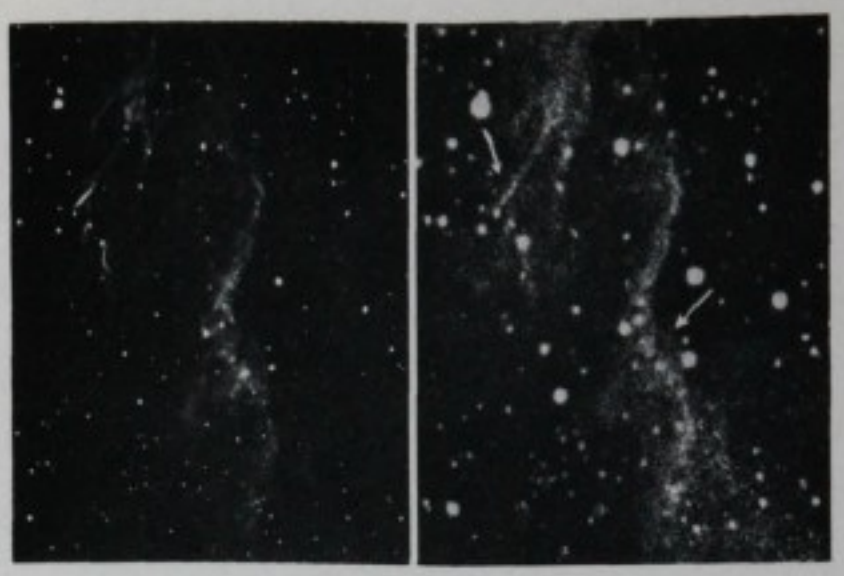


Fig. 4. Two of Fessenkov's chains in NGC 6992 are shown here. At the left is the region photographed with the Crossley reflector; at the right is the Maksutov camera representation. Fessenkov points out that with even slight overexposure his chains blend into solid bands.

they regard as typical star chains. Our other illustrations show details of the different regions, the comparison photographs being made either by N. U. Mayall at Lick Observatory with the 36-inch Crossley reflector or by J. C. Duncan with the 60-inch reflector at Mount Wilson Observatory. The reproductions of the two sets of pictures to corresponding scales were prepared by Roger Lynds, of Berkeley.

The Russian pictures were taken from printed halftones in the *Astronomical Journal* of the Soviet Union and, therefore, do not do full justice to Fessenkov's photographs. Nevertheless, it is apparent that in the process of reproduction the grain of the plate was brought out in nearly all cases, so that the loss in definition was probably relatively small. Careful examination of the illustrations shows beyond doubt that many of the star chains indicated by arrows on Fessenkov's photographs cannot be seen on the American pictures.

There are, however, a few cases in which the chains of starlike objects indicated by Fessenkov appear to be in the nature of gaseous condensations within the filaments. Finally, there are two or three intriguing groupings of stars, some of which do, more or less, coincide with the nebulous filaments, while others run roughly parallel to such filaments. Whether such a group of stars is physically related to the nebula remains doubtful. On the whole, the evidence does not support the hypothesis that stars are being formed within *these* filaments of the nebulosity.

Fessenkov and Rojkovsky have also developed a theoretical basis for their ideas of the formation of star chains. As we saw in our discussion of star clusters (October, 1953, page 313), the tides of the Milky Way set a lower limit to the density a cloud must have before it can condense into a star. This density is of the order of 10^{-22} gram per cubic centimeter. Let us now suppose that a star has somehow been formed out of a suitable cosmic cloud of gas and dust. If the cloud has not been used up in the formation of the single star, but contains enough mass to form additional stars, then the tidal action of the newly formed star sets a new and greater limit for the density of the remaining cloud before it can condense to produce a second star.

When the star-cluster precepts are applied, we find that 10 times the mass of the tide-producing object divided by the cube of the distance between it and the center of the second stellar condensation gives a limiting density of the order of 10^{-19} gram per cubic centimeter. This exceeds by a factor of 1,000 the density required for the formation of the first star, because in the hypothetical star chains of Fessenkov the linear separations between neighboring stars are of the order of 0.1 parsec.

It is easy to compute that if the mass of the first star is similar to that of the sun, and if the second star is to make its appearance at a distance of 0.1 parsec (3×10^{17} centimeters), the tidal action of the first star is far more effective than the tidal effect of the central mass of the Milky Way. The condition imposed upon the density of the cloud is, therefore, much more stringent when the second star is to be formed than when only one star is produced.

If the chain consists of several additional stars, then the tidal criterion continues to require a density of the order of 10^{-19} gram per cubic centimeter with-

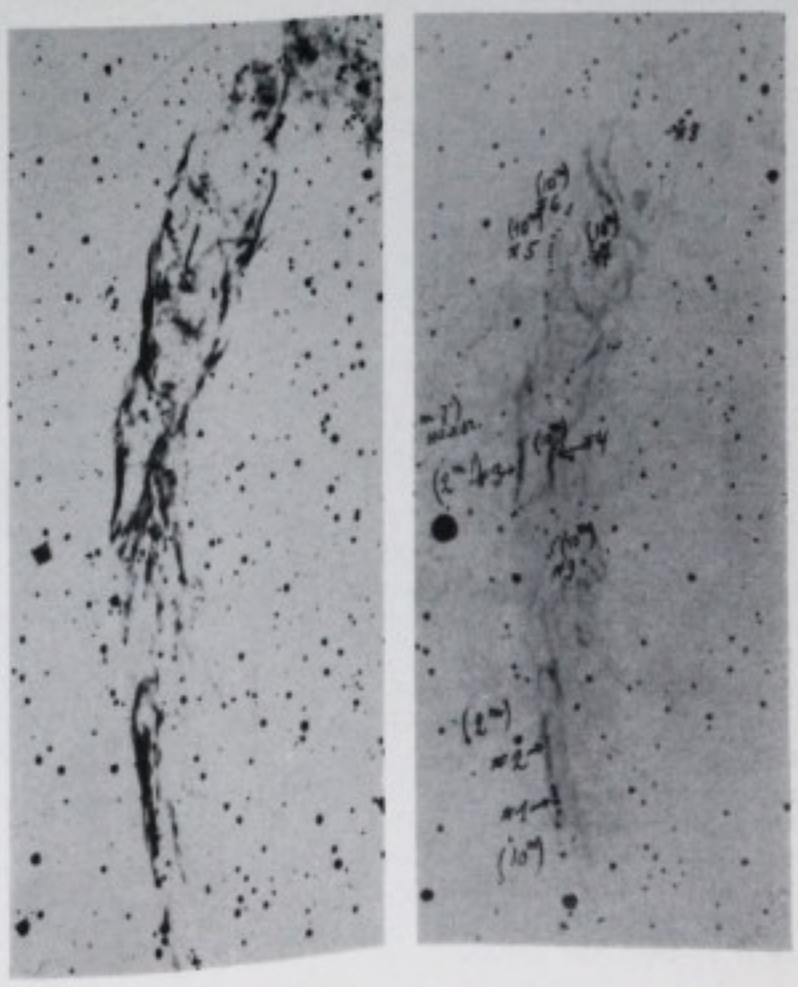


Fig. 5. The drawing to the right, by Fessenkov and Rojkovsky, is based upon several photographs with the Maksutov camera, with exposures from 2½ to 10 minutes. They have labeled nine possible chains, adding in parentheses the exposure time in minutes that brings out each most clearly. On the left is a negative reproduction of a 60-inch Mount Wilson reflector plate by John C. Duncan.

in the filament of the nebulosity.

Since the mass of a hydrogen atom is slightly more than 10^{-24} gram, the critical density for successive star formation within the filament must correspond to at least 100,000 hydrogen atoms per cubic centimeter. This value seems excessive to me. My own data led me to believe that the number of hydrogen atoms within a typical filament of the Veil nebula might be of the order of 1,000 per cubic centimeter. In a recent article in the *Astrophysical Journal*, J. W. Chamberlain presented several different hypotheses concerning the structure of the Veil nebula, corresponding to densities between 171 and 46,000 hydrogen atoms per cubic centimeter, for different modes of excitation. Among these, he expressed preference for the one that corresponds to about 500 hydrogen atoms per cubic centimeter.

Unless the distance of the Cygnus filamentary nebula is very much greater than 1,000 parsecs—the value used by Fessenkov—the lower densities estimated by Chamberlain would allow only a mass of the order of 1/100 that of the sun to be contained within the volume allotted to the formation of a single star within a chain. We do not know the distance of the Veil nebula. Chamberlain mentions the possibility of 1,600 parsecs, although he adopted 500 for his computation. S. Cederblad gave it as 400 parsecs in his catalogue, while J. H. Oort used 500 parsecs in his work on nebulae. Even allowing for the uncertainty of this distance, however, it does not now appear probable that we can adjust the criterion of tidal instability to give us the correct value of the required nebular density.

The conclusion of all of this is not too comforting. We are tempted to accept as real some such star chains as the one north of the North America nebula and perhaps one or two among those announced by Fessenkov. Few astronomers will deny that there are real chainlike groups of stars, such as the remarkable formation that involves the stars Lambda and Phi Orionis. On the theoretical side the ideas of Edgeworth and some of the ideas of Fessenkov are undoubtedly sound, but the details of both the observational data and the theoretical interpretation remain indistinct.

Theoretically, it may be necessary to take into account electromagnetic forces, which in D. H. Menzel's terminology produce a "pinch effect." This effect may account for the filamentary structure of solar prominences, and it may also explain the filamentary character of the Veil nebula. Since gravitation of a condensation upon itself is not entirely adequate, it may also be necessary to invoke G. P. Kuiper's new ideas regarding the "snowball" accretion of material by chemical forces.

Moving the Greenwich Observatory

FOR more than two centuries, positional astronomy has been largely dominated by the work done at the Royal Greenwich Observatory. Our knowledge of accurate star positions, the proper motions of the stars, and the motions of the moon and planets all rest to a considerable extent upon Greenwich observations. When the observatory was founded in 1675, on a country hilltop overlooking the Thames east of London, its site was very advantageous. However, in recent years the enormous growth of London has engulfed Greenwich, and heavy industrial smoke and city lights have now made the location quite unsuited for astronomical observations.

In 1947, steps were begun to transfer the Greenwich Observatory to a much more favorable site at Herstmonceux Castle, about 50 miles southeast of London, near the battlefield of Hastings. The new location is about 20′ east and 37′ south of the original observatory at Greenwich. The castle itself, built in 1440, had been recently modernized and was well suited for office space, and the 370 acres of grounds offered ample room for erecting instruments.

The move to Herstmonceux was long delayed by the postwar economic crisis, but is now actively under way. Some of the following information on the state of the transfer has been kindly communicated by H. G. Barker, secretary of the Greenwich Observatory.

A solar building was first completed, and it has been in use for several years. It is equipped with a 4-inch photoheliograph and a spectroheliograph. At present a group of buildings is under construction northwest of the castle to house the meridian instruments. The building for the Greenwich transit circle is finished, that for the photographic zenith tube is under way, and housing for the Melbourne transit circle will begin shortly. Completion of this part of the removal is expected by the end of this year.

The next stage will be chiefly the installation at Herstmonceux of the six large equatorial telescopes. These are the 36- and 30-inch reflectors, the 28- and 26-inch refractors, and the astrographic telescope, now at Greenwich, and a new Schmidt camera. Work has already been started on this stage, which should be finished by June, 1955.

The third stage is the erection of a large building to the southwest of the castle to accommodate the Nautical Almanac Office, the time department now at Abinger, the chronometer repair shop, and the observatory workshops. The planning for this building is now in hand; it is hoped to place the contract late this year for completion by the end of 1955. The time shift to Hertsmonceux therefore cannot take place until early 1956.

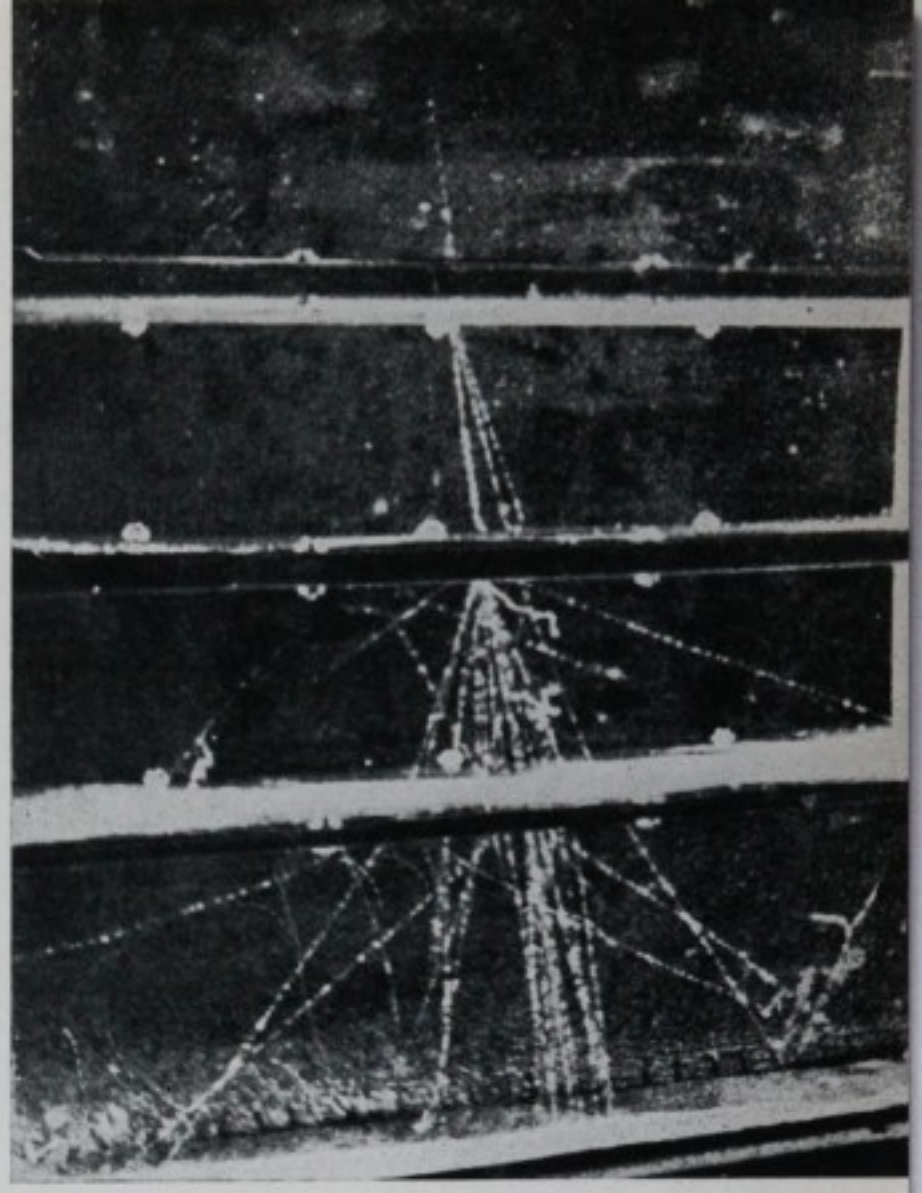
One historic instrument, the Airy transit circle, will not be taken to Herstmonceux (see *Sky and Telescope*, May, 1953, page 180). Universal time is the local time on the meridian of longitude passing through this telescope. While the observations for the determination of time will be transferred to Herstmonceux, the old zero meridian of longitude will be retained, so that the definition of Universal time will not be changed.

The largest telescope at Herstmonceux will be the 100-inch Isaac Newton reflector. The mirror for this has been ground and figured, and is awaiting test, but the design of the mounting has not been finally decided upon. It is unlikely that the Isaac Newton telescope can be in use before 1958.

The entrance on the south side of the castle at Herstmonceux, as it appeared in 1948, while interior renovations were under way in preparation for the transfer of the Greenwich Observatory. The building is shaped like a hollow square, with a large interior court.

The Story of Cosmic Rays--III

By W. F. G. Swann, *Director*
Bartol Research Foundation, Franklin Institute



In this cloud chamber picture, a cosmic ray electron struck the uppermost of three lead plates (6.3, 6.3, and 0.7 millimeters thick, respectively). At least four particles sped from the first to the second plate, the tracks of two of them being superimposed. At the second plate considerable multiplication occurred, caused probably by unseen photons from the first plate. Scattering (change of direction) is very pronounced at the third plate. Photograph by Lewis Fussell, Jr.

3. Types of Apparatus Used in Cosmic Ray Experiments

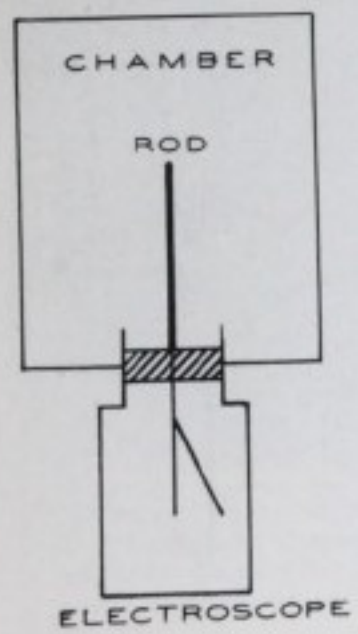
Ionization Chamber. This is essentially a gas-filled closed vessel provided with a central insulated rod which can be connected to a suitable instrument for measuring electrical potential. The rod is charged to a potential sufficiently high in relation to the vessel itself to attract and clear out ions as fast as they are formed, allowing no time for recombination of the positive and negative ions in the gas. Under these conditions, the electric current departing from the rod is proportional to the rate of production of ions in the vessel by external radiation. It is, of course, necessary to take precautions against radioactive contamination, whose radiations would compete with the external radiation.

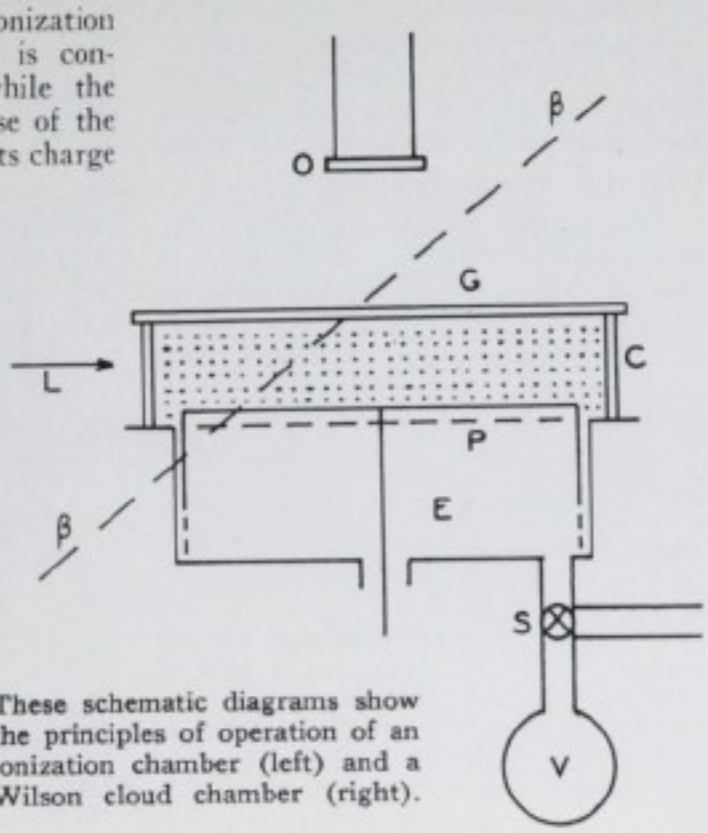
An ionization chamber provides information on the relative intensity of the external radiation when averaged in all directions. It is not suitable for measuring the intensity from a fixed direction.

When ionization chambers are sent to high altitudes, automatic procedures have to be devised for recording the observations. In one arrangement, the current-measuring instrument records its readings on a moving photographic film. In another form, the ionization current is measured by electronic devices which ultimately transmit the information to ground stations by radio.

In the diagram at the left below is shown a simplified form of ionization chamber. The insulated rod is connected to the electroscope, while the chamber is connected to the case of the electroscope. As the rod loses its charge the leaf of the electroscope changes its deflection.

Cloud Chamber. Essentially, the cloud chamber is a vessel filled with gas saturated with water vapor. A sudden expansion is created in the gas, and this causes the water to condense in droplets on any ions present in the chamber. As a rule, the expansion is caused to occur immediately after some ionizing ray has passed through the vessel, the ionizing ray being detected by suitably arranged Geiger counters which, through electronic devices, initiate the expansion. Geiger counters are described below.





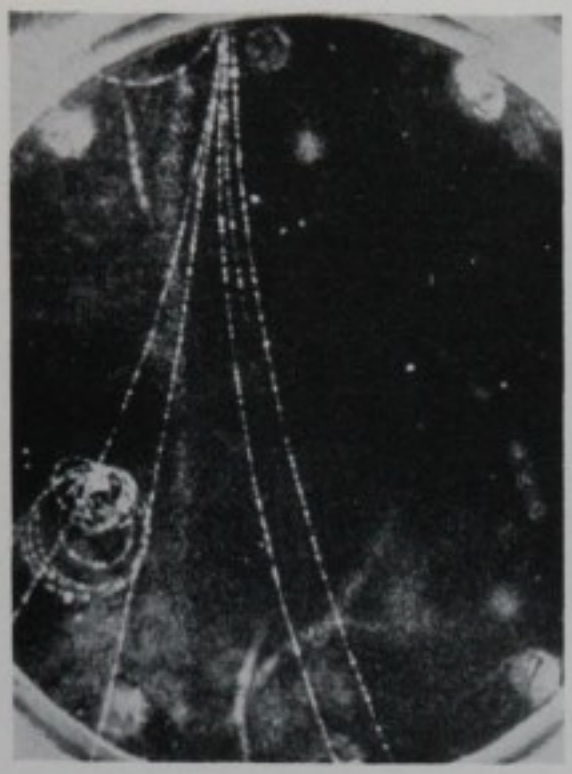
These schematic diagrams show the principles of operation of an ionization chamber (left) and a Wilson cloud chamber (right).

The ionizing ray generates ions along its path and the water droplets condense upon these ions, rendering the path visible.

In the schematic diagram of the cloud chamber, P is the piston, which suddenly drops to the position of the dashed line when the stopcock, S, is opened, connecting the space E with the evacuated vessel, V. The glass cover, G, is cemented to the glass cylinder, C. The light, L, illuminates the fog droplets that condense upon the ions created by a fast charged particle, β. The objective of the photographic equipment is O.

Moving charged particles are bent into curved paths when in a magnetic field, the bending in a field of a particular strength being determined by the product of the mass and the velocity, that is, the momentum of each moving particle. To observe this bending for a particular particle, and therefore determine its momentum, we operate a cloud chamber in a magnetic field. Particles with the greatest momentum have paths of the least curvature.

Theories of ionization show that the number of ions produced along the path of an ionizing ray depends for the most part upon the velocity of the ray for a fixed electric charge. The law relating the velocity to the ionization per centimeter of path is known from theoretical calculations. Thus, by observing the cloud chamber droplets that form along a particular path, which gives the number of ions per unit length, we are able to determine the particle's velocity. Combining this velocity with the product



This Anderson-Neddermeyer cloud chamber picture shows both positively and negatively charged electrons.

of the mass and the velocity yielded by the bending of the path in the cloud chamber, we are able to arrive at both the mass and the velocity of any particle of known charge, and so we are able to calculate the energy of the particle.

The photograph above was taken with a cloud chamber in a magnetic field of 7,900 gauss, by C. D. Anderson and S. H. Neddermeyer, at an altitude of about 14,000 feet. It illustrates how the magnetic field causes positive particles to curve in one direction (in this case, to the right), while negative particles curve in the opposite direction. From their curvature and ionization, the particles are recognized as electrons. Of the three positrons, the middle track is short and faint. One of the three negative electrons made the strongly curved track at the top of the picture.

The closely wound spiral at the lower left is probably the track of a "knock-on" electron arising from an elastic collision with the fastest moving negative electron.

Another example of a cloud chamber photograph, at the right, shows the track of a mesotron moving from *A* to *B*, where it died, giving rise to an electron whose trail, thinner because of its lesser ionizing power, extends to *C*.

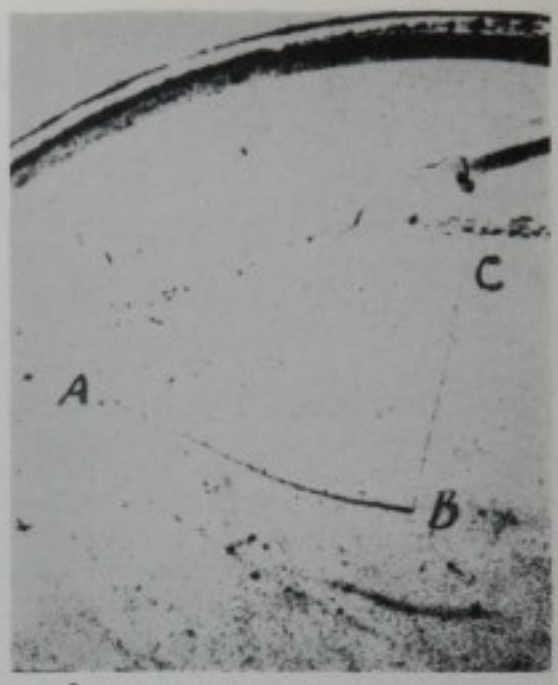
Geiger Counter. One of the most useful devices for cosmic ray measurements is the Geiger-Mueller counter, one form of which is illustrated here. An ionizing ray passing through it precipitates an electric discharge which can be amplified and recorded. A single Geiger counter records particles from all directions. However, by using two counters in combination, and arranging that a record is made only when the two counters discharge simultaneously, one is able to select from all ionizing rays only those that pass through both counters and therefore travel within the geometrical limits prescribed by the two counters. Frequently, three or more counters are placed in tandem, since by this means it is possible to eliminate certain spurious effects more thoroughly.

The picture below illustrates a simple Geiger-Mueller counter. A tungsten wire runs coaxially through a metal cylinder enclosed in a glass tube filled with a suitable gas at a reduced pressure. When a proper potential difference is maintained between wire and cylinder, the cosmic ray passing through the cylinder precipitates an electrical discharge which operates a recording mechanism.

The two cosmic ray telescopes shown at the right below are designed to record only rays passing vertically downward. Each of the three units comprised in a single telescope is a combination of three simple Geiger counters, overlapping so as to avoid dead spaces. In this arrangement, the upright counters can be slid into place as indicated by the arrow. The electrical circuit is planned so that a telescope will not record if there is an accompanying discharge from one of the upright counters.

Trains of Geiger counters are frequently sent aloft by attaching them to a number of balloons, and the records are radioed to ground stations. The Geiger counters are usually accompanied by pressure-measuring instruments to determine the altitude gained, which may be as great as 25 miles. Occasionally Geiger counters and associated equipment have been carried to the vicinity of 100 miles high by means of rockets.

Photographic Emulsions. Within recent years photographic emulsions have been used to perform a function similar to that of a cloud chamber. Ionizing particles, passing through the emulsion,

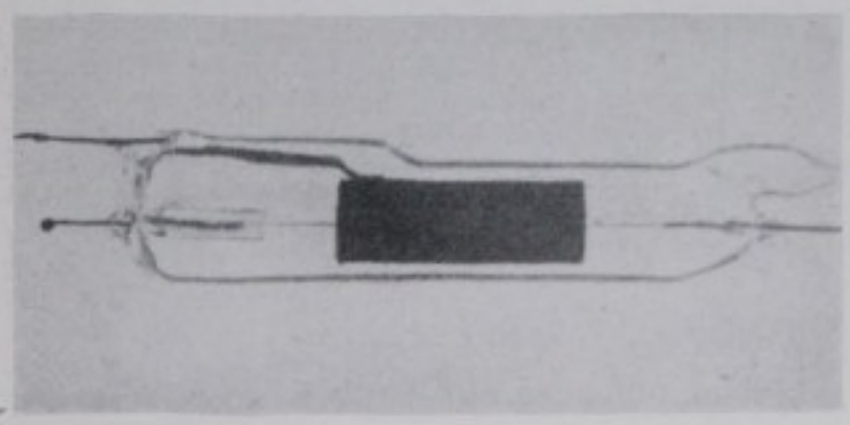


A cloud chamber photograph by R. P. Shutt, S. de Benedetti, and T. H. Johnson, records the death of a mesotron.

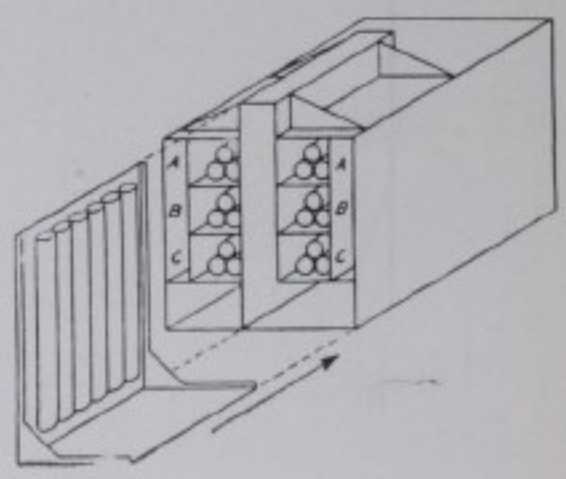
render developable those silver grains which they strike, so the paths of the particles can be observed. Some of these emulsions are a millimeter thick.

Compared with the cloud chamber, an emulsion has the advantage that it is continuously sensitive and requires no expansion process to initiate its operation. Its disadvantage is that only short ranges of tracks are observable, although lengths of several millimeters have been obtained in tracks that lie parallel to the surface of the emulsion. Such a length in the emulsion is comparable in energy loss with about a thousand times that length in air.

Photographic emulsions do not lend themselves readily to experiments involving deviations of the particles in a magnetic field. Their chief service has been in enabling us to observe the consequences of impact of a cosmic ray particle with the nucleus of an atom. When such an event occurs, a number of tracks are frequently observed emanating from the point of collision. By examining the ranges of these tracks, the variation of ionization along them as determined by the number of developable grains, and the angular spread of the tracks, it is possible to derive information as to the mass and energy of the particles responsible for them. In the interpretation of such data, considerable use is made of

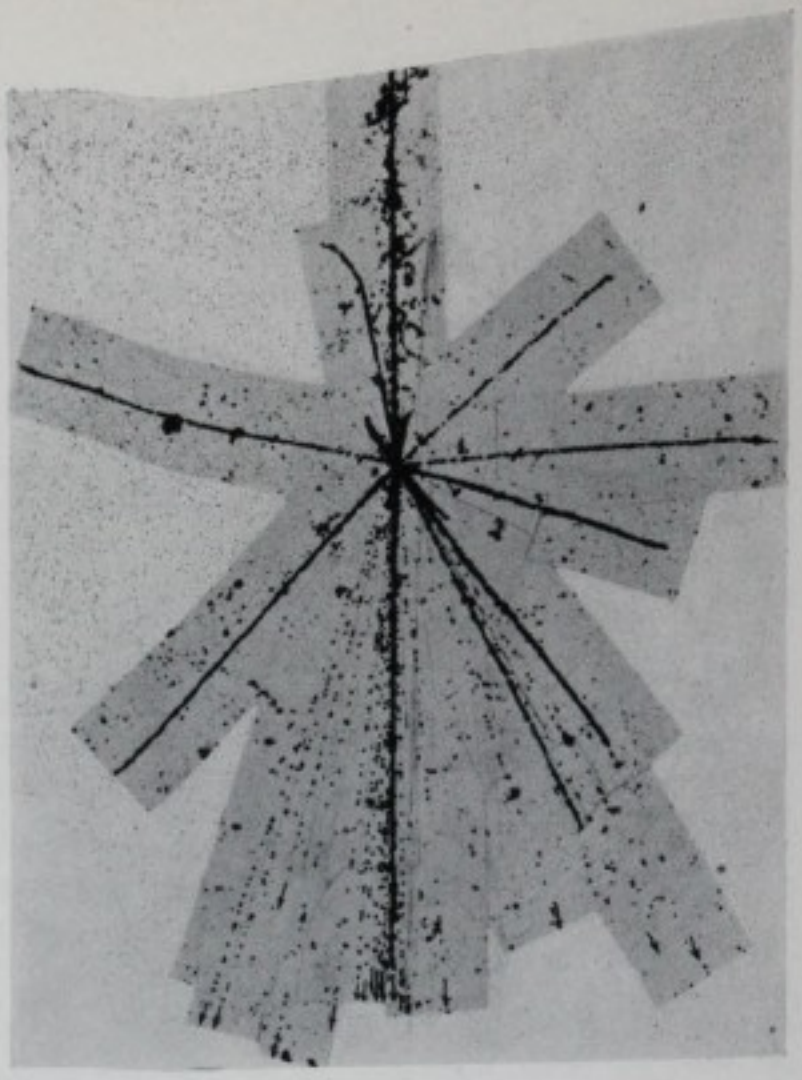


At the left is shown a simple form of Geiger-Mueller counter.



At the right is the design of a pair of Geiger-counter telescopes, described in the text.

As shown by the front-cover picture, strings of five or more balloons were used at Ft. Churchill to carry aloft units of apparatus such as the one these physicists are preparing.



On a balloon flight that carried photographic emulsions to record cosmic rays, this "star" was procured by C. Powell. The incoming particle (downward from the top of the picture) was presumably a sulphur nucleus, atomic number, 16 ± 1. It collided with silver or bromine in the emulsion, to produce a fluorine nucleus (downward to the bottom) and 25 particles, consisting of protons and pi-mesotrons. From the Physical Society of London.

the conservation principles that assert that the energy and momentum of the original particles hitting the nucleus are equal to the sums of the energies and momentums of all the resulting particles.

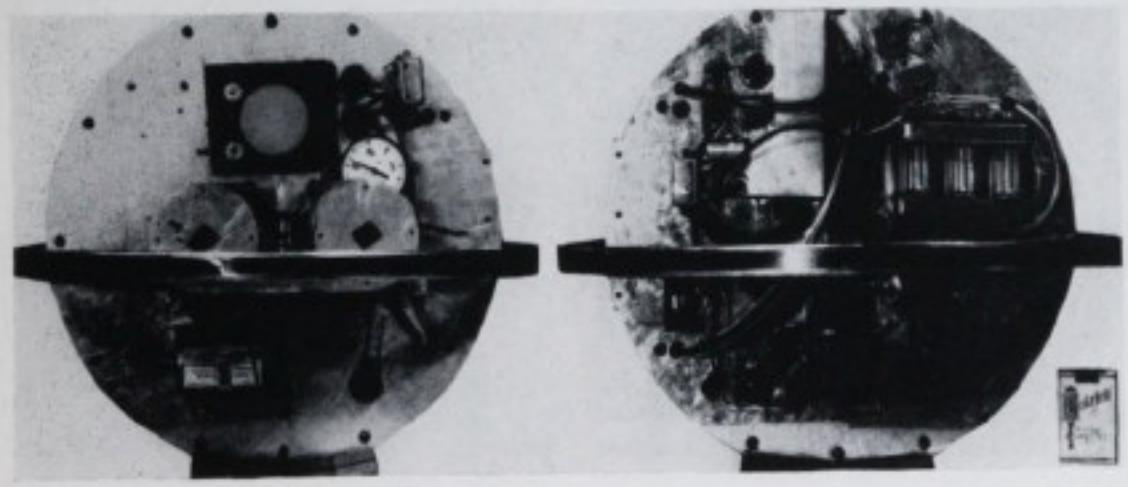
It was by means of photographic emulsions that pi-mesotrons were originally discovered, and such plates have played a great part in extending our knowledge of these particles and other mesotrons.

Combinations of Apparatus. Apparatus of the foregoing kinds has been used in all sorts of combinations. Ionization chambers have been used in conjunction with Geiger counters. Cloud chambers of various shapes have been employed. Sometimes two cloud chambers separated by a space in which the rays pass through a magnetic field have been utilized. Cloud chambers have been partially filled with plates of absorbing material, sometimes many in number, for the purpose of observing secondary rays generated by particles in traversing the material.

Large areas covered with Geiger counters have been employed and several such areas have been arranged in tandem, as in the cosmic ray telescope. The insertion of blocks of absorbing material between the areas has permitted studies of the production of secondary radiation, frequently referred to as cosmic ray showers, resulting from one or more rays that enter the apparatus.

The front-cover picture and the one above to the left are from a project conducted jointly by the National Geographic Society and the Bartol Research Foundation. Observations were made during the summers of 1949 and 1950 from Ft. Churchill, near Hudson Bay, Canada. The high latitude of 58° corresponds to 69° north magnetic latitude. The purpose of the balloon experiments was, among other things, to ascertain whether the primary cosmic ray intensity at the top of the atmosphere is considerably greater near the north magnetic pole than it is at lower magnetic latitudes. The decision concerning this matter has an important bearing on the question of the magnitude of the sun's magnetic field.

(To be continued)



These are front and rear views of the combination apparatus used recently by G. W. McClure's cosmic ray expedition to South America. This very compact assembly contains trains of Geiger counters, an ionization chamber, a camera, and a cathode ray oscillograph. The scale is indicated by the pack of cigarettes.

PLANETARIUM CONFERENCES

On January 28-29, at the Buhl Planetarium in Pittsburgh, representatives from seven of the major planetarium installations in the United States met for the third planetarium executives conference. They discussed exhibits, exchange and joint construction of special equipment, promotion and publicity, radio and television presentations, scripts for lectures, sound and music, and art work. In addition to Buhl Planetarium personnel, the conference was attended by staff members from the Fels Planetarium in Philadelphia, Griffith Observatory in Los Angeles, the Hayden planetariums in Boston and New York, Morehead Planetarium in Chapel Hill, and the Morrison Planetarium in San Francisco.

Speakers from both large and small planetariums are being asked to take part in the program of the planetarium section of the American Association of Museums, which will hold its annual meeting in Santa Barbara, Calif., May 26-28. The planetarium section, under the chairmanship of John Patterson, Boston Museum of Science, will meet Thursday evening, May 27th. All planetariums not sending representatives are invited to send 50 copies of leaflets or folders describing their programs to Mr. Patterson at Science Park, Boston 14, Mass., for distribution at the planetarium section meeting at Santa Barbara.

American Astronomers Report

Here are highlights of some papers presented at the 90th meeting of the American Astronomical Society at Nashville, Tenn., in December. Complete abstracts will appear in the Astronomical Journal.

Distances of Galaxies

Regularly scheduled operations with the 200-inch telescope began in November, 1949, and a systematic attack on extragalactic problems has been in progress since that time. In his symposium paper, Dr. Allan R. Sandage, Mount Wilson and Palomar Observatories, gave a report on results concerned with the distance scale of the universe.

The certainty with which we can establish galaxy distances depends on the accuracy of magnitude determinations of faint objects, for we apply the rule that the fainter an object is in comparison with others of its type the farther away it is. With the Hale reflector, Dr. W. A. Baum has nearly completed his observations of standard stars in 10 selected areas to the 19th magnitude, and it is intended to extend the scale to below magnitude 22 in three of these areas.

In an associated program, the 200-inch has been used to investigate the stellar contents and group characteristics of the nearby resolved galaxies, to provide a new calibration for the distance scale. Results already announced include the work with the Andromeda galaxy by Dr. W. Baade, from which it has been definitely established that classical Cepheid variable stars are 1.5 magnitudes more luminous than previously supposed, which implies that galaxies whose distances are found from Cepheids are 1.9 times more distant than had been believed.

A second correction to extragalactic distances arises from the inadequate scale of apparent magnitudes available in 1936 when Hubble's survey of galaxy distances was complete. When the 200-inch was put into operation, Hubble undertook a redetermination of distances to nearby galaxies beyond M31, using photoelectric magnitude sequences. The program has been carried on after his death, and the first results, announced by Dr. Sandage, indicate that the correction to the distance scale beyond the local group may be considerably greater than 1.9.

For instance, the new 200-inch photographs of M81, in Ursa Major, isolate one Cepheid, seven blue supergiant irregular variables, and 20 normal novae. These three types of stars give an average of 27.1 for the distance modulus of this galaxy, establishing a preliminary new distance of 7,000,000 light-years. This is four times as great as the former 1,700,000 light-years, based on Hubble's 1936 modulus of 24.0. Further observations are being made to check these results.

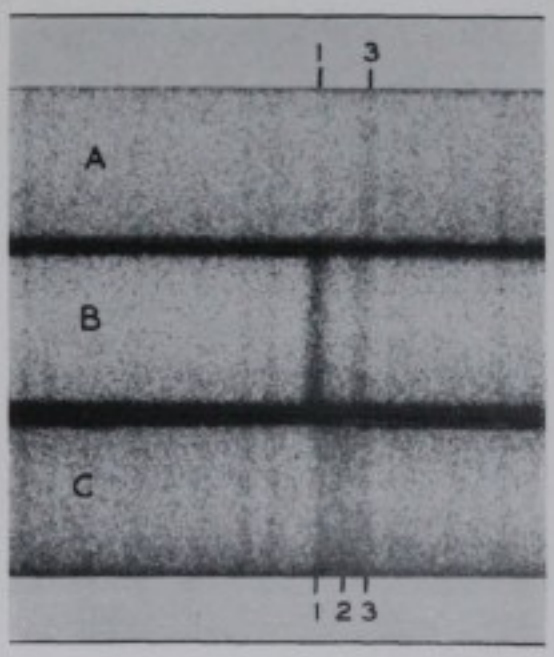
Dr. Sandage said, "It is impossible from this one isolated case to draw a general conclusion concerning the distance scale for nebulae beyond the local group since the second correction, due to the 1936 calibration difficulties (which adds to the Baade correction), may vary from nebula to nebula. The problem is far from settled but the M81 results indicate that the general distance correction factor could be as large as four."

Observational Tests for Intergalactic Matter

Is the space between the galaxies entirely empty? If finely divided intergalactic matter exists in the form of gas and dust it could perhaps be detected by the same methods that have shown that interstellar space in our own galaxy is far from empty. The existence of interstellar gas was first indicated by sharp absorption lines of ionized calcium (the H and K lines of the Fraunhofer spectrum) which did not show the Doppler motion of the stars themselves. The existence of interstellar dust was later proven by its dimming and reddening effect on distant stars.

Dr. A. E. Whitford, of Washburn Observatory, University of Wisconsin, has examined the limits set by these tests. Spiral galaxies out to about 100 million parsecs show no detectable reddening. This means that any intergalactic gas-dust mixture like that in the Milky Way must have a density at least 100,000 times less than the density in the solar neighborhood. The test for gas by the absorption-line method runs into the difficulty that the gas is not standing still; the outer portions would show an increasing red shift like that of the galaxies. A broad shallow absorption line would therefore be expected for distant systems. Reasonable estimates of the state of ionization of calcium indicate detection would be possible for a total density of 5×10^{-28} grams per cubic centimeter. Since such absorption has not been noticed on existing spectrograms, a density as high as 10^{-27} grams per cubic centimeter can be ruled out.

Within the local group of galaxies, where there is no expansion, the radio line of hydrogen at 21 centimeters could perhaps be used as a test, and the detection limit comes out to nearly the same total density as for the ionized calcium test. This limit is of the same order as the mean density indicated by Hoyle's theory of continuous creation.



In these spectra of Upsilon Sagittarii, 1 and 2 are satellites of the hydrogen-beta line, 3. Spectrum A is 57 days before inferior conjunction; B, seven days before; C, 21 days after; corresponding to the situations A, B, C, in the diagram on the facing page. University of Michigan photographs.

Upsilon Sagittarii

Upsilon Sagittarii is a spectroscopic binary star with a period of 138 days, and its spectral peculiarities have long aroused attention. The brighter component is a supergiant *B*8 star with abnormally strong helium and metallic lines; it is nearly 100 times as large in diameter as the sun, and 50,000 times as luminous. Although the fainter component cannot be observed directly, the light variations that occur when it should be eclipsed by the brighter star suggest that it is much smaller and hotter than the *B*-type primary.

Dr. Dean B. McLaughlin, University of Michigan Observatory, has studied a remarkable feature of the spectrum, first noted by Miss Annie J. Cannon at Harvard: the "satellites" that accompany the hydrogen lines. Variable in nature, these satellites cannot be due to the *normal* atmosphere of the smaller, companion star.

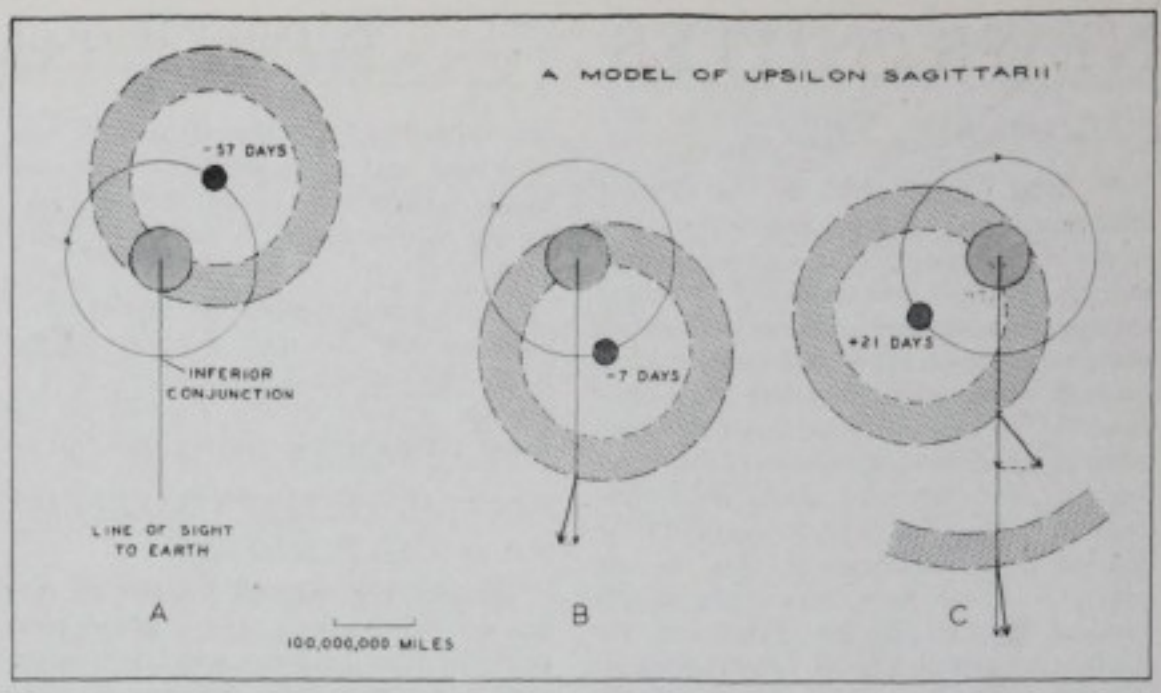
They are always shifted to the violet of the normal position of the hydrogen line, indicating that they are caused by absorption by hydrogen gas approaching the observer, as noted earlier by J. S. Plaskett.

The satellites are visible *only* during that half of each orbital period when the fainter star is nearer to the earth than the bright star; in other words, they are

produced only by the light of the bright star shining through a very extensive expanding atmosphere surrounding the fainter star, according to Dr. McLaughlin. The long duration of this effect requires that the gaseous envelope extend outward from the faint star far enough to involve the bright star. Only when the latter is nearer to us than the faint star will its light reach us directly without being absorbed by the hydrogen gas; then no satellites will be visible.

The satellites are not always present. The Michigan spectrograms cover the years 1921-1953 with a few gaps. During 1923-1928, in 1934, and again in 1949-1953, the satellite lines were conspicuous, but they were absent in 1935-1947. The faint star is thus intermittently emitting hydrogen clouds; it is similar in type to the star P Cygni. Even during the active periods, the eruption of the hydrogen is spasmodic, for sometimes there are double satellite lines, as shown in the lowest of the three spectra reproduced here. At inferior conjunction, when the small star is nearly in line between us and the large star, the maximum shift of a satellite to the violet is 360 kilometers per second; this appears to be the relative velocity of eruption of the gas. This corresponds nearly to the spectrum marked B and the situation at B in the diagram.

At A in the diagram, little if any of the bright star's light that is traveling toward the earth can shine through the expanding hydrogen, and the satellites are absent. At C, two shells of gas are shown, one presumed to have originated about seven days after inferior conjunction, the other nearly 21 days after inferior conjunction, when spectrum C was taken. The components of the expanding motion that are in the line of sight to the earth are different for the two shells of gas, and they produce absorption lines with differing apparent velocities in spectrum C.



Dean B. McLaughlin's interpretation of Upsilon Sagittarii.

Red Shifts in Faint Galaxies

Spectroscopic observations of extragalactic nebulae have been made for some 3½ years with the 200-inch telescope, and Dr. Milton L. Humason, Mount Wilson and Palomar Observatories, presented results of this important observing program. He is seeking to refine the Hubble "law of red shifts," that as galaxies appear fainter and fainter their spectral features are shifted more and more to the red.

First, he reobserved some of the faintest clusters of galaxies accessible to the 100-inch telescope on Mt. Wilson, and in every instance the 200-inch confirmed the early results and provided spectrograms of better quality.

Then he worked to the spectroscopic limit of the 200-inch, with the largest red shift observed to date of the order of 61,000 kilometers per second, when expressed as a Doppler shift.

Finally, Dr. Humason has attempted to get uniform data at increasing distances, to furnish mean points for the correlation curve of red shifts and apparent magnitudes. In this he has succeeded very well; he presented a table of the number of galaxies in a cluster for which the red shift was observed, and the corresponding red shift. For instance, in the Corona Borealis cluster, 8 galaxies give a red shift of 21,530 kilometers per second; another group of 2 in Coma Berenices gives 21,580 kilometers per second. Then the list runs: 1 each at 25,660 and 28,300; 2 each at 39,270, 40,770, 42,830, 45,910, 47,620, and 49,600; 1 each at 51,770, 52,460, 54,890, and 57,610; and 2 at 60,920 kilometers per second.

If these red shifts are real Doppler shifts of recession from us (and the universe is expanding), then a relativistic correction must be applied to the above measured values to reduce them to true velocities. Displacements smaller than 3,000 kilometers per second would not be seriously affected by this correction, but at 20,000 kilometers per second the reduction is about four per cent, and the true velocity for 60,000 would become 54,000 kilometers per second.

Dr. Humason's work indicates that the logarithm of the red shift increases linearly with apparent magnitude over the entire observable range from the Virgo cluster (1,140 kilometers per second) out to the Hydra cluster (60,920 kilometers per second). Individual clusters fit this relationship so closely that their magnitudes are evidently little or not at all affected by patchy intergalactic obscuring matter.

The dispersion used at Palomar for all faint galaxies is 370 angstroms per millimeter. With this dispersion, the probable errors for red shifts smaller than 30,000 kilometers per second is of the order of ±35 kilometers per second. For larger shifts it is ±50 kilometers per second; at 60,000 kilometers per second, the uncertainty is less than half of one per cent. Thus, as Dr. Humason pointed out, at the present time all of the significant uncertainties in the red-shift relation are in magnitude determinations.

The spectroscopic observations are not made easily, however. For fainter objects than magnitude 19, the H and K lines become almost obliterated by the spectrum of the night sky. But shifts of 60,000 kilometers per second displace the H and K lines some 800 angstroms, to the region of wave length 4700. Still larger red shifts will displace H and K beyond the long wave-length limit of blue-sensitive plates, but into a more favorable region of the spectrum, since the night-sky bands are not so strong from 4700 to 5200 angstroms.

The large red shift has another advantage, for the emission line of oxygen at 3727 angstroms is brought out of the ultraviolet. The problem is to find late-type spirals, in which 3727 is bright, among the myriads of specks that are extremely distant galaxies. Dr. Humason also stated that detecting more distant clusters of galaxies is a serious problem. Although over 1,000 clusters have now been found in survey photographs with the 48-inch Schmidt telescope on Palomar Mountain, it is possible that none of these is more distant than those for which observations have already been made. If this is the case, then discoveries of fainter clusters will have to depend on chance finds with the 100-inch and 200-inch telescopes.

Dr. Humason has collected red-shift observations of some 580 galaxies, while at Lick Observatory Dr. N. U. Mayall has measured the red shifts of about 280. About 100 objects have been observed in common, and the two lists will therefore include some 760 individual galaxies. The Palomar and Lick results will be ready for publication in 1954.

NEWS NOTES

By Dorrit Hoffleit

URSA MAJOR CLUSTER

As long ago as 1869, R. A. Proctor discovered that five of the seven stars in the Big Dipper have a common proper motion. Later investigators, searching catalogues of proper motions and radial velocities, found about a hundred other stars that appeared to share their motion. With intensive and more accurate modern observations, however, the number has been whittled down until now only 11 stars can with certainty be identified as members of this moving cluster. These have been exhaustively studied by Dr. R. M. Petrie, of the Dominion Astrophysical Observatory at Victoria, B. C., and Dr. B. N. Moyls, of the University of British Columbia. They used proper motion data furnished by the U. S. Naval Observatory and spectrograms taken for the purpose at Victoria.

The 11 stars move through space in parallel paths whose convergent point is 130 degrees away, at the eastern edge of Sagittarius. Such a convergent point is analogous to the radiant point of a meteor shower, except that a meteor radiant is a divergent point. The Ursa Major cluster stars, traveling together at a speed of 15.2 ±0.8 kilometers per second, form the nearest of the moving clusters, at an average distance of 75 light-years from the sun. The members range from a bright bluish star nearly 100 times more luminous than the sun to a faint star quite similar to the sun. In space these stars occupy an elongated volume whose length is about 30 light-years.

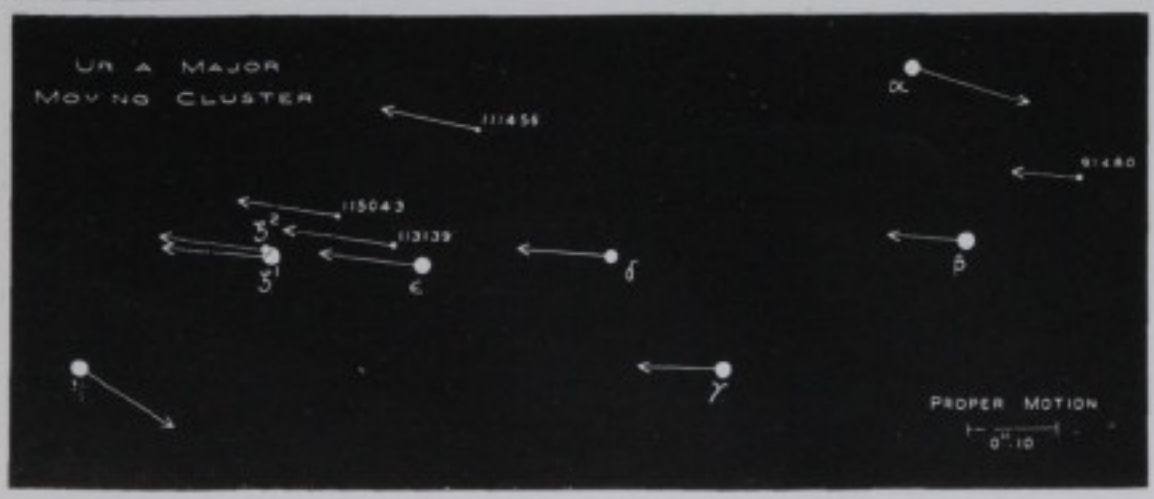
The Canadian scientists report their work in the *Monthly Notices* of the Royal Astronomical Society and give a popular account in the *Journal* of the Royal Astronomical Society of Canada.

PARTIAL ECLIPSE OBSERVED AT 10 CENTIMETERS

During the partial eclipse of the sun on February 14, 1953, astronomers at the Tokyo Astronomical Observatory used a 2-meter radio reflector to make observations at a wave length of 10 centimeters (3,000 megacycles); and the results are analyzed by Kenji Aoki. The magnitude of the eclipse was 0.452, and it lasted visually for an hour and four minutes. With the radio equipment, however, it started three minutes earlier and lasted three minutes later, indicating that at 10 centimeters the sun is five per cent larger than in visual light. The radio "light curve" was, moreover, not symmetrical as it would have been for a uniform disk, the solar limb being three times brighter than the central region. This is attributed to a bright region around some sunspots, believed to be due to a local excess of the electron densities in the chromosphere and corona.

The Stars of the Ursa Major Moving Cluster

Star	Apparent Magnitude	Type	Proper Motion	Direction of Proper Motion	Radial Velocity	Luminosity ⊙ = 1	Radius ⊙ = 1	Distance from Centre
			per yr.		km./sec.			l.y.
H.D. 91480	5.2	A8	0.078	64°	− 10.4	4	1.2	23
β UMaj	2.4	A0	0.090	71	− 12.2	48	2.7	18
γ UMaj	2.5	A0	0.096	86	− 13.5	46	2.6	10
δ UMaj	3.4	A0	0.105	88	− 16.5	48	2.7	3
H.D. 111456	5.9	F5	0.109	90	− 9.1	2	1.3	10
ε UMaj	1.7	A0	0.114	96	− 7.4	91	3.7	7
H.D. 113139	4.9	A4	0.121	96	− 8.7	4	1.0	8
H.D. 115043	6.7	G0	0.113	100	− 8.3	1	1.1	11
ζ¹ UMaj A	2.4	A2	0.123	105	− 8.2	44	2.8	12
ζ¹ UMaj B	4.0	A8	0.123	105	− 8.2	10	2.0	12
ζ² UMaj	4.0	A3	0.120	103	− 12.4	11	1.5	13



Because two of its stars do not belong to the Ursa Major cluster, the Big Dipper is changing its apparent shape. In about 100,000 years, the stars will reach positions at the ends of the proper-motion vectors in this diagram. The table is from the "Journal" of the Royal Astronomical Society of Canada.

IN THE CURRENT JOURNALS

COPERNICUS AND LUTHER: A CRITICAL STUDY, by Wilhelm Norlind, **Isis,** September, 1953. "Indeed I never found a writer on astronomy who did not quote Luther's words as characteristic of Luther's poor opinion of Copernicus . . . we must, in my opinion, regard the 'famous' expression . . . as an interpolation not consistent with the text."

ROCKETS AND THE UPPER ATMOSPHERE, by Homer E. Newell, Jr., **Scientific Monthly,** January, 1954. "Many important questions concerning the upper atmosphere remain unanswered. For some of them the rocket seems at present to be the best, or even the only, means for obtaining definitive answers."

SCIENCE FOR ITS OWN SAKE, by Sir Edward Appleton, **Science,** January 22, 1954. "The radio-astronomical story is therefore far from being fully told, but even already one can record achievements in these three centres of Cambridge, Sydney and Manchester—partly in competition and partly in collaboration—worthy to be ranked with the greatest feats in the art of experiment."

AAVSO ENDOWMENT FUND

The National Science Foundation is supporting the work of the American Association of Variable Star Observers for the year 1954. Thereafter, however, the society will be self-supporting, and it is currently conducting a drive to establish a fund of at least $250,000.

Contributions are requested in any amount from individuals and groups interested in furthering the work of the AAVSO. The money will be invested as principal, and only the interest will be used for the expenses of operating the society and maintaining the headquarters and office of the recorder, Mrs. Margaret W. Mayall, at 4 Brattle St., Cambridge 38, Mass.

Co-chairmen of the endowment fund committee are the society's first vice-president, Dr. Charles H. Smiley, Ladd Observatory, Brown University, and the secretary, Clinton B. Ford.

Contributions, payable to the AAVSO Endowment Fund, should be sent to Percy W. Witherell, treasurer, AAVSO, 84 Prince St., Jamaica Plain 30, Mass.

SUBSCRIPTIONS TO "METEORITICS"

The annual subscription price of *Meteoritics* (the first number of which was discussed in News Notes, February, 1954) to members and nonmembers of the Meteoritical Society is $4.00 (to student members, $2.00), regardless of the number of issues published. Orders should be sent to the secretary of the Meteoritical Society, Dr. John A. Russell, Department of Astronomy, University of Southern California, Los Angeles 7, Calif.

Amateur Astronomers

Detroit and Montreal Amateurs Plan Eclipse Expeditions

THE Detroit Astronomical Society will locate its solar eclipse station north of Park Falls, Wis., close to the central line of totality, for the June 30th eclipse. About 20 members of the society will make up the party. There will be several telescopes ranging from a 6-inch to a 12.5-inch; one 30-inch focal length camera, one 45-inch focal length camera, and one 16-mm. movie camera with a telephoto lens. A short-wave radio, battery operated, will receive time signals from WWV. Necessary equipment to establish exact latitude and longitude will be taken.

The group plans accurate timing of the contacts; photography of the different phases of the eclipse, of the flash spectrum, if possible, and of the inner and outer corona. In addition, recording of sky intensity at the zenith before, during, and after the eclipse, will be undertaken, as suggested by Dr. G. Van Biesbroeck, of Yerkes Observatory.

Taylor Z. Russell
Chairman, DAS eclipse committee
20052 Regent Drive
Detroit 5, Mich.

Tentative plans for a railroad tour to the path of totality of the June 30th eclipse were announced in "Skyward," the monthly newsletter of the Montreal Centre of the Royal Astronomical Society of Canada. Anyone interested should get in touch with Miss Isabel Williamson, 5162 Belmore Ave., Montreal, to find out whether plans have crystallized and if space is available.

Plans call for the reservation of an entire Pullman sleeper, which would leave Montreal Sunday evening, June 27th, arriving at the destination, Mattice (near Hearst), Monday evening. The sleeper will be put on a siding and serve as a hotel. Tuesday will be devoted to observing arrangements for Wednesday's eclipse. The sleeper will be picked up early Thursday morning and arrive in Montreal Friday morning.

The cost per person, for rail transportation, berth, porter service for the entire trip, would be $67.91 lower berth, $64.45 upper berth (Canadian). A dining car would be available for meals en route; in Mattice, meals could be had at the Mattice Hotel.

WASHINGTON CONVENTION PROCEEDINGS

As long as the supply lasts, the **Proceedings** of the general convention of the Astronomical League, held in Washington, D. C., September 4-7, 1953, are available from R. C. Maag, 816½ S. Massachusetts, Sedalia, Mo. The price is $1.50 each. There are 128 mimeographed pages, and the contents include a synopsis of the convention, reports of officers and section chairmen, council actions, the substance of all papers given, reports from societies, and the names and addresses of the convention registrants.

This publication was edited by C. H. Holton, of the Atlanta Astronomy Club, with typing assistance of Emily Campbell. It is published by Mr. Maag, of the Central Missouri Amateur Astronomers, and Mrs. Milton Dale, Mrs. Foster Scotten, and members of the Sedalia Junior Astronomy Club.

SOUTHEAST CONVENTION

The 1954 convention of the Southeast region of the Astronomical League will be held on April 24-25 at Bradley Observatory, Agnes Scott College, Decatur, Ga. Three professional astronomers will speak: Dr. W. A. Calder, of Agnes Scott College; Dr. Karel Hujer, University of Chattanooga; and Dr. K. N. Rao, University of Tennessee. There will be exhibits, observing, and a discussion on planning club activities.

The Atlanta Astronomy Club is host society, and all interested societies and individuals are invited to attend, to bring exhibits, and to take part in the program. The convention chairman is F. C. Boland, 97 Dartmouth Ave., Avondale Estates, Ga.

JUNIOR TELESCOPES BY MAIL

Several years ago the making of small 8-power refracting telescopes for children was described to readers of **Sky and Telescope** (September, 1949). By this method, over 600 telescopes were made in the classes I supervised at the Cleveland Museum of Natural History, from 1949 until the spring of 1952. During this same period, 365 telescopes were sent by mail to other cities.

After a period of inactivity, at the end of 1952 I found that 64 requests had piled up, and I again started making up kits. In 1953, I answered a total of 169 requests for information, and as a result I received orders for 216 telescope kits, from 68 different persons. The farthest shipment was to a Baptist mission in Turkey, which I sent without charge. Among the orders, one was for 33 kits, another for 20, two for 15. They indicated 14 places where a group was to assemble its own telescopes, many in high schools; some of the groups have formed junior astronomy clubs.

The typical letter that I received reads, in the usual case, "Please send me instructions for building a simple and inexpensive telescope." Of course, sometimes I am asked for "all the information there is about astronomy," or "information about flying saucers."

Until I run out of the brown plastic tubing, I will continue to make up kit parts. Inquiries from adults conducting junior groups are especially welcome, as it is for group work that the kits are especially adaptable.

Frank A. Myers
19200 N. Park Blvd.
Shaker Heights, Cleveland, Ohio

THIS MONTH'S MEETINGS

Buffalo, N. Y.: Buffalo Astronomical Association, 7:30 p.m., Museum of Science. Apr. 7, Paul W. Stevens, Rochester Academy of Science, "Solar Eclipse Plans."

Chicago, Ill.: Burnham Astronomical Society, 3:30 p.m., Adler Planetarium. Apr. 11, Dr. Harry Nelson, Augustana College, "Visitors from Outer Space."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Apr. 23, Dr. Gerard P. Kuiper, Yerkes Observatory, "The Age and Evolution of the Earth and Planets."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Lone Star Gas Co. auditorium. Apr. 26, John M. Hulme, "White Dwarfs."

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., City Hall. Apr. 13, Clarence R. Smith, "Old Books on Astronomy"; Frank Hancock, "Astronomy in the Bible."

Lake Charles, La.: Lake Charles Amateur Astronomers Club, 7:30 p.m., McNeese State College. Apr. 8, Dr. Sam F. Adams, "Time."

Lorain, Ohio: Black River Astronomical Society, 8 p.m., Spang Bldg. Apr. 7, G. Diedrich, "Observing with a Purpose."

Marietta, Ohio: Marietta Astronomical Society, 7:30 p.m., Cisler Terrace. Apr. 29, Prof. John E. Sandt, Marietta College, "The Expanding Universe."

Minneapolis, Minn.: Minneapolis Astronomy Club, 7:30 p.m., Public Library. Apr. 7, Wentsell Frantzich, "Celestial Navigation; The Spring Skies."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Apr. 7, Dr. Robert I. Wolff, College of the City of New York, "Astronomy and the Atom."

South Bend, Ind.: St. Joseph Valley Astronomical Society, 7:30 p.m., YMCA. Apr. 1, Mrs. G. Stoneburner, "Sound"; John Urednick, "Constellations."

Teaneck, N. J.: Bergen County Astronomical Society, 8:30 p.m., Observatory, 107 Cranford Pl. Apr. 14, H. A. Rey, "Spring Constellations—A New Way to See Them."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Dept. auditorium. Apr. 3, U. Sherman Lyons, U. S. Naval Observatory, "Astronomy and the Tides."

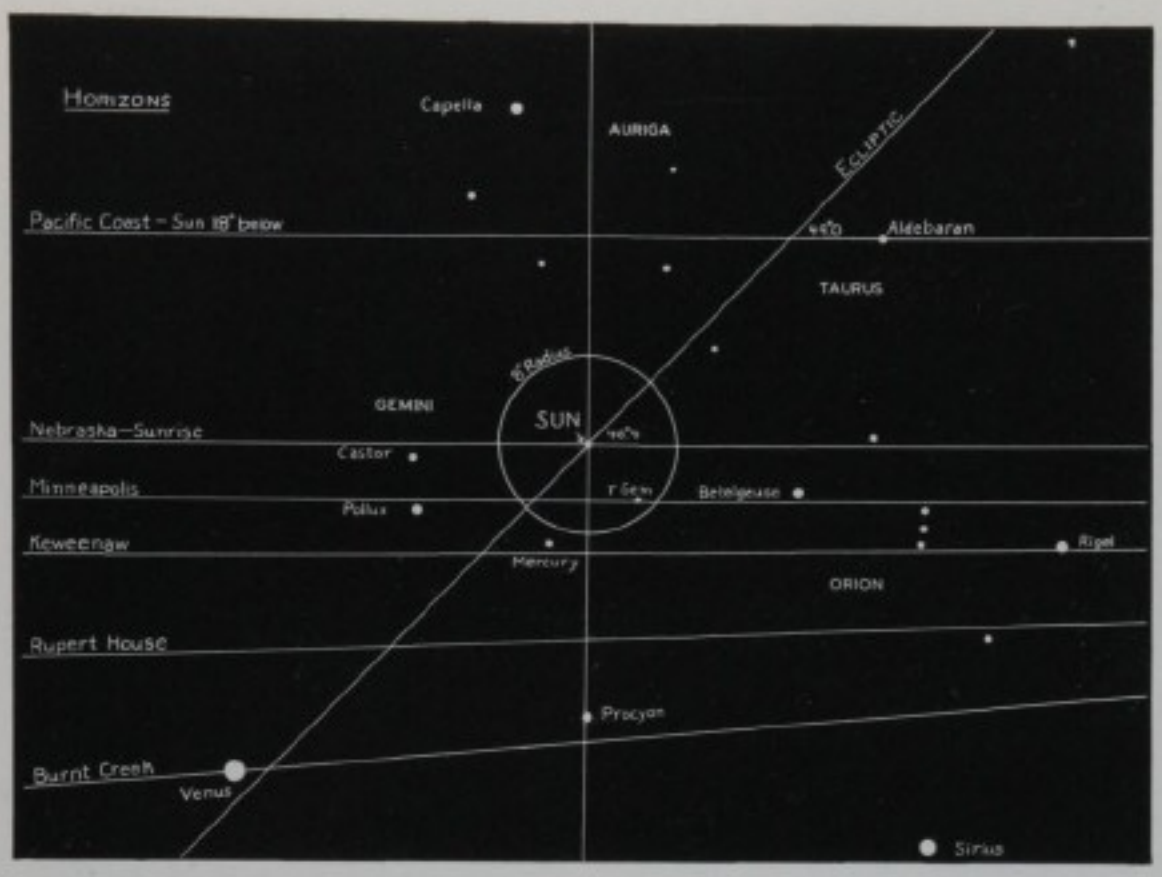
JACKSON ASTRONOMICAL SOCIETY

A new astronomical society has recently been formed in Jackson, Mich., with nearly a score of members after its first few months. Meetings are at 7:30 p.m. on the second and fourth Thursdays of each month, in the Jackson Public Library. Special observing meetings are held on weekends. Observing equipment includes a 6-inch and an 8-inch telescope. Other members have smaller instruments; three are working on 6-inch mirrors, and a 4-inch richest-field is under construction by the writer.

Allen Bell, president
Jackson Astronomical Society
1103 Hamlin Pl.
Jackson, Mich.

The Sky at Totality

By Paul W. Stevens
Rochester Academy of Science



The sky as seen from the United States and Canada during totality. The sun's corona may extend in some directions several times the diameter of the sun and moon. The vertical line is perpendicular to the Nebraska horizon where mid-eclipse occurs at sunrise.

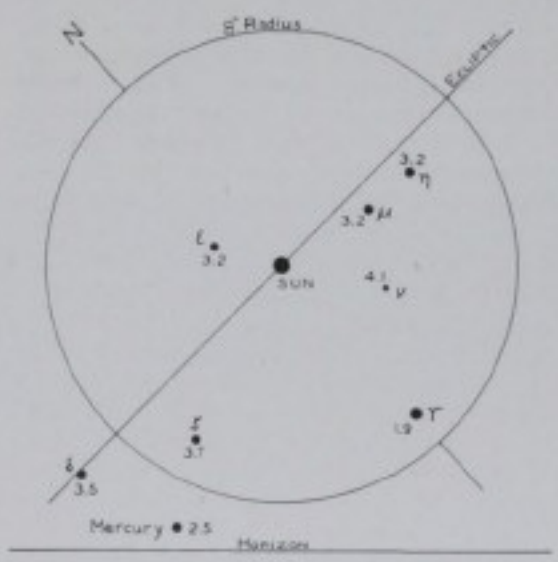
A TOTAL ECLIPSE of the sun may well be the grandest spectacle in nature, both for sheer beauty and for the rapidity and dramatic fashion in which the sequence of events takes place. As the diamond ring signals the onset of totality, the awe-inspiring corona suddenly flashes into view. In the excitement of the fleeting seconds, this may be all the unprepared observer will notice during totality. A 1st-magnitude star or planet may attract attention, particularly Venus and Jupiter, which are brilliant enough to be sometimes seen with the unaided eye in full daylight. Observations of fainter objects are not only interesting in themselves, but may give astronomers and meteorologists useful information about the state of the earth's atmosphere.

To make the most of the precious moments in finding how faint a star can be easily seen, the observer should become familiar with the celestial pattern in advance by careful study of a map. This precaution is doubly necessary if he uses prism binoculars, which can be recommended for the brilliance and width of their field. The two charts show the planets and bright stars that will be visible around the sun and moon during totality; the large one is for the naked-eye observer, the small one for use with binoculars.

The gnomonic projection has been used so straight-line horizons at the time of totality may be drawn for several stations on the central line. During the 20 minutes that the axis of the moon's shadow moves across portions of the United States and Canada, the apparent motion of the sun among the stars may, for our purpose, be neglected. If the large chart is held with the horizon line in its proper position for the observer's location, the objects should be shown in their true relative positions in the sky at the time of totality.

The first bright star to be detected will probably be Capella, above and slightly left of the sun. In Nebraska, it should be continuously visible to the unaided eye while the brilliance of the dawn, first increasing, will fade as the eclipse advances below the horizon.

Aldebaran will be the only other star easily seen without binoculars. Stars in Orion and Gemini will be so near the horizon for observers in the United States that their detection will depend more on the absence of haze near the ground than on the sky darkening resulting from the eclipse. If it is a very clear morning,



The field of stars immediately surrounding the sun, for observers with binoculars. All stars shown are in Gemini. Visual magnitudes are indicated. For ξ and η Geminorum, which are variable stars of small amplitude, the expected brightnesses on the day of the eclipse are given.

Castor should be easily observed at Minneapolis, while Pollux should be seen with the same facility from the Keweenaw peninsula. A search for Rigel and Orion's Belt could be made at the latter station after Betelgeuse has first been identified. All these stars may be easily seen at Rupert House in Canada, while Procyon will be the real test at Burnt Creek. As the sun will be much higher in the sky, it may be more difficult to detect Procyon at Burnt Creek than Castor at Minneapolis or Pollux on the Keweenaw peninsula.

Three planets of interest will be in this part of the sky although only two are shown on the map. Jupiter will be occulted by the sun during the eclipse and thus will be invisible from any part of the world. Mercury may be seen by lucky observers on the shore of Lake Superior. Near inferior conjunction, it will be a thin crescent of magnitude 2.5, matching δ Orionis, the uppermost star in Orion's Belt. Venus will be visible at stations east of 69° west longitude, and at magnitude −3.5 it will be so brilliant that it should be easily detected with the unaided eye wherever it is above the horizon.

On the chart, a circle of 8° radius has been drawn around the sun, an area suitable for survey with binoculars. This field is shown enlarged in the smaller chart, with the addition of fainter stars. It will be convenient to sweep this field with a rotary motion so that the moon stays just outside the field of view, and with the corona showing.

The value of visibility observations of stars during the eclipse is that they measure the brightness of the sky during totality. This will take careful planning in order to make every moment count during the fleeting seconds of maximum darkness. It is suggested that each of the several observers in a given party watch for the appearance of certain stars, so that a wider range of the sky can be covered than would be possible for an individual. Valuable advice in carrying out such a program is given by John Q. Stewart's article, "The Shadow of the Moon," in **Sky and Telescope** for May, 1945. The same article emphasizes the usefulness of careful descriptions of the color and distribution of sky brightness, as the moon's shadow sweeps past the observer at totality.

The best procedure is to establish the party at the observing station while the sky is still completely dark. First watch for the zodiacal light, and note the time and extent of its visibility. Then time the first appearance of dawn. Record should be kept of the time of disappearance of key stars in the morning twilight, particularly in constellations like Auriga and Taurus which can later be easily

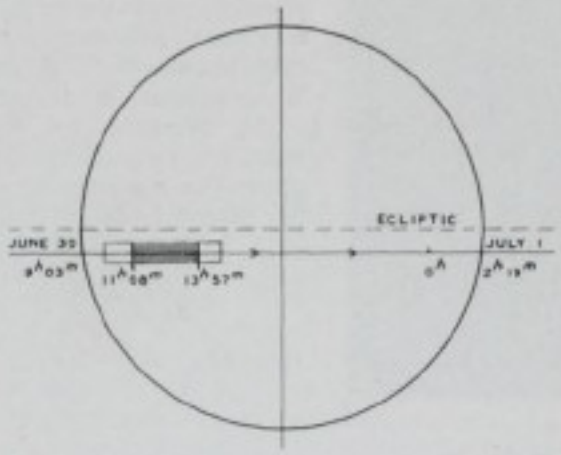
located above the eclipsed sun. For rapid identification during the brief period of totality, the observer is urged to use brilliant objects as guides to nearby fainter ones. Examples are Capella for the Kids (ϵ, η, and ζ Aurigae) and Aldebaran for the Hyades.

In this connection, my experience in the morning twilight of August 18, 1953, may be of interest. Mercury, in Cancer 18° from the sun, was easily seen with the naked eye. I saw in 6 x 30 binoculars the stars γ, δ, and η Cancri, the last only of magnitude 5.5. Without the bright planet as a guide, it is doubtful that these stars would have been found except with setting circles, as the twilight was brightening too rapidly to allow time for sweeping.

Observers located where total eclipse takes place below the horizon may see certain stars vanish in the dawn, only to reappear before totality begins. In this case, the times of reappearance and of final disappearance after totality should be recorded. At Pike's Peak and other Rocky Mountain stations, stars in Perseus and Andromeda should be watched for this purpose, as Auriga and Taurus may be too low in the sky.

A remarkable feature of this eclipse is that during it Jupiter will be behind the sun. Occultations of planets by the sun occurring at a total solar eclipse are very rare, although it is commonplace to find a planet, especially Mercury or Venus, in the sun's neighborhood at such a time. Because of periodicities that apply to Jupiter alone, described in **Sky and Telescope** for May, 1947, the giant planet will be close to either opposition or conjunction with the sun at the times of central eclipses during the present century.

The accompanying diagram shows the circumstances of this solar occultation, which will last 17 hours and 16 minutes, more than three times the duration of the eclipse itself from first to last contact with the earth. The sun's disk is indicated as a circle, with the ecliptic the horizontal line through its center. Jupiter's path is marked to show where the planet is located for the duration of the eclipse; totality is indicated by the dark band, while the intervals before and after, when the earth cuts only the penumbra of the moon's shadow, are also indicated.



The path of Jupiter during its occultation by the sun on June 30-July 1. Events are indicated in Universal time.

The apparent path of Jupiter relative to the sun is from east to west. This is because the sun seems to be moving eastward among the stars more rapidly than the planet, as a result of the earth's revolution. Jupiter is approaching its ascending node and actually moves from west to east along a path that slants upward to the left relative to the ecliptic as one views it with north at the top.

Jupiter, with an orbital inclination of only 1.3 degrees, remains nearer the ecliptic than any other planet. A complete analysis of the frequency of solar occultations of planets would be of interest, involving their distances from the sun as well as the inclinations of their orbits to the plane of the ecliptic. In the cases of Mercury and Venus, transits in front of the sun are well-known phenomena, but very little has been written about their occultations by the sun. Both transits and occultations are relatively rare, but the latter are much more common than transits. This is because at superior conjunction the geocentric latitude of each planet tends to be much less than at inferior conjunction.

CORRECTION

In the tables of Mercury transit times published in the February issue, page 116, for Contact III the value for O—C for observer No. 15 should be —20, and for observer No. 16 should be —18.

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evening, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sunday, 2:00 to 5:30 p.m. Admission free. Spitz projector.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Manager, A. F. Jenzano.

CHARLESTON, W. VA.: *Hillis Townsend Planetarium.* Public Library Building, Charleston, W. Va.

SCHEDULE: Saturday, 11:15 a.m. Special showings on request. Admission free. Spitz projector. Director, Louise L. Morlang.

CHEROKEE, IA.: *Sanford Museum Planetarium.* Sanford Museum, 117 E. Willow St., Cherokee, Ia.

SCHEDULE: Monday, 8 p.m. (except August). Admission free. Spitz projector. Director, W. D. Frankforter.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 2-1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:00 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 1, Mo., Chestnut 2215.

SCHEDULE: Saturday, 3:00 p.m.; Sunday, 3:00 p.m. Spitz projector. Director, Charles G. Wilder.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P. O. Box 27787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday, Thursday, and Friday at 8:30 p.m.; Saturday and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NASHVILLE: *Sudekum Planetarium.* Children's Museum, 724 2nd Ave. S., Nashville 10, Tenn., 42-1858.

SCHEDULE: Sunday, 2:45, 3:30, 4:15. Spitz projector. Supervising lecturer, James C. Foster.

NEWARK: *Newark Museum Planetarium.* 49 Washington St., Newark 1, N. J., Mitchell 2-0011.

SCHEDULE: Saturday and Sunday, 2:30 and 3:30 p.m. Admission free. Spitz projector. In charge, Ray Stein.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Trafalgar 3-1300.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. General manager, J. M. Chamberlain.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

PORTLAND, ORE.: *Oregon Museum of Science and Industry Planetarium.* 908 N.E. Hassalo St., Portland 12, Ore., East 3807.

SCHEDULE: Saturday and Sunday, 3:00 p.m.; Wednesday, 4:00 p.m.; Saturday show for children only, 10:30 a.m. Spitz projector. Director, Stanley H. Shirk.

PROVIDENCE: *Roger Williams Planetarium.* Roger Williams Park Museum, Providence 5, R. I., Williams 1-5640.

SCHEDULE: Wednesday at 3:30 p.m.; Saturday at 10:30 a.m., 2:30 and 3:30 p.m.; Sunday, 2 to 5 p.m. Admission free. Spitz projector. Director, Maribelle Cormack.

SAN FRANCISCO: *Morrison Planetarium.* California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif., Bayview 1-5100.

SCHEDULE: Daily (except Monday and Tuesday) at 3:30, 7:30, and 9 p.m.; also at 2 p.m. on weekends and holidays. Academy projector. Manager, George W. Bunton.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Sunday 4:00 p.m. Admission free. Spitz projector. Director, Ernest T. Luhde.

ST. PETERSBURG: *Rice Planetarium.* 4700 Lakeview Ave., St. Petersburg, Fla.

SCHEDULE: Daily, 10:30 a.m., 2:30 and 8 p.m.; Sunday, 2:30 p.m. Spitz projector. Director, Laban Lacy Rice.

Filming the Total Eclipse

By Peter A. Leavens

A telescopic view of the sun rising 85 per cent eclipsed in a hazy sky over the Continental Divide at Butte, Mont., July 9, 1945. The picture was taken by the author with a 4-inch lens of 120 inches focal length, with a focal-plane shutter giving an exposure estimated at 1/2,000 second. The sun is less than a degree high; compare its diameter with its distance above the horizon. Similar pictures will be possible in the vicinity of Sioux Falls, S. D., on June 30th.

FAVORABLE circumstances of the total eclipse on June 30th offer unusual opportunities for American and Canadian camera enthusiasts to take a variety of photographs. The eclipse is easily accessible, crossing regions of relatively high population density and well located with respect to all kinds of transportation. The season is good, and the only unpredictable circumstance will be the weather.

The eclipse will occur at an altitude low enough so that terrestrial foregrounds can be used to enhance both still and motion pictures. This permits even simple Brownie-type cameras to snap the scene during the Baily's beads stages before and after totality, when the sun is not reduced to the faintness of totality and surrounding daylight remains to illuminate the landscape. Picture possibilities for more advanced still or movie equipment, and with telescopes, are broad indeed.

The twin cities of Minneapolis and St. Paul both lie within and near the center of the total eclipse line. There the sun rises at 4:32 a.m., Central standard time, already 36 per cent hidden by the moon. Totality occurs at 7½ minutes past 5 o'clock, with a duration just exceeding 75 seconds in the northwest metropolitan section of Minneapolis. The sun's height at mid-eclipse will be about five degrees, sufficient for good observations and for pictures that include man-made structures or attractive natural surface views.

Amateur photo fans who do not journey out of the urban area will find the 32-story Foshay Tower an excellent subject to complement the eclipse. Its height allows shooting from far enough away so that the sun's disk can be made to appear impressively large in relation to the building. A short drive west of the city reaches beautiful rural settings around Lake Minnetonka, where water reflections of the happening above will show in pictures.

For an abundance of other spots, with the sun lower but more deeply eclipsed, cameramen can range the 200 miles southwest to Sioux Falls, S. D. Conversely, they may go across Wisconsin, or to the Keweenaw peninsula in upper Michigan. From a belt in Ontario, Quebec, and Labrador, the entire eclipse can be filmed fairly high in the morning sky.

As explained by D. C. Whitmarsh in February (page 134), filters are among the essential accessories. A pair will be helpful in Minnesota: the conventional Tiffen 4X, equivalent to an aperture decrease of two stops, and the much heavier 4.0 Kodak Wratten filter (No. 96), which transmits but 0.0001 of the received light and is delivered in 2- and 3-inch gelatin squares, with glass mounting for adapter rings optional.

Up in clear sky, sun disk images of perfect density result from the Kodak 4.0 filter, a diaphragm of f/16, and 1/100 second on black-and-white films rated at Weston 50, including the popular Plus X, Supreme, Isopan, and so on. This corresponds to f/6.3 for Kodachrome, Ektachrome, and Ansco Color, and f/9 on Kodacolor. A one-stop increase is needed if the sun is just an hour off the horizon, and two stops are needed if it is within 30 minutes of the horizon.

For 12 minutes after sunrise on June 30th, an accurate exposure for positive color will be obtained with the Tiffen 4X filter, f/32, and 1/500-second shutter speed if the air is transparent. Thick haze or thin clouds allow slower shutter speeds, or no filters, and direct exposure-meter readings are necessary in such cases.

Planning for still pictures should specifically involve the dawn's early glow. The sun is well to the north of east, with the near-solstice twilight lengthy, especially at latitude 45° or higher. Cameras and equipment should all be secured on sturdy tripods and pointed to the chosen composition by 3 o'clock in the morning. First, take the scene with an exposure half as long as that indicated by a light meter pointed at the brightening northeastern sky; this will **outline** foreground subject matter. The partly eclipsed sunrise then can be taken later on the same film. These are telephoto shots for which the following lenses should prove adequate: 6-inch for 35-mm. film; 12-inch on 120 size; and up to 20-inch for 4 x 5.

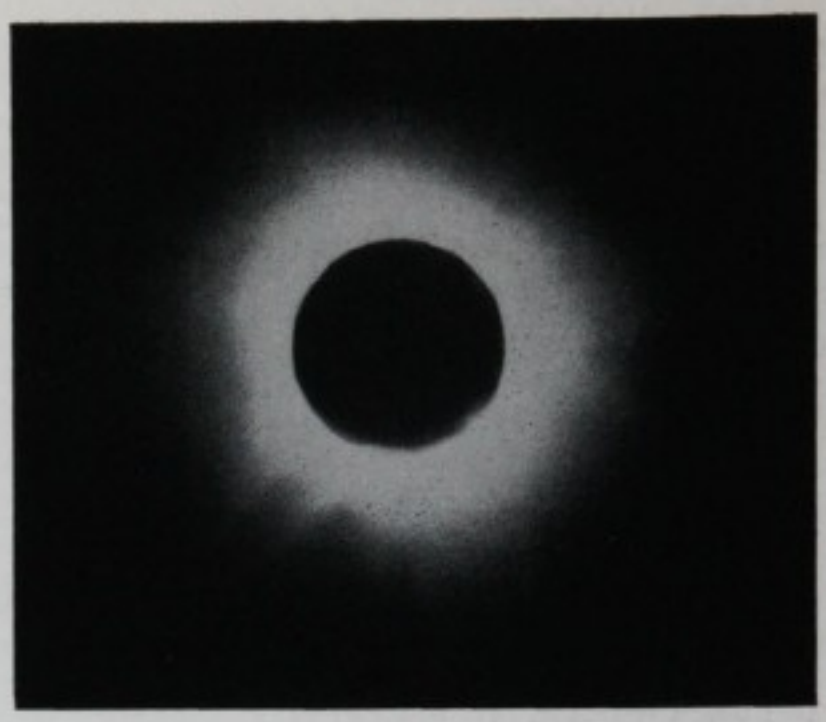
With regular roll and sheet-film cameras without telephoto lenses, skip the dawn profile and make on one film a series of progressing partial phases up to and timed for total eclipse, tripping the shutter exactly every five minutes. The longer exposure required for totality will finally bring in horizon illumination and land silhouettes.

For the many observers photographing the sun when it is fairly low in the sky, I would recommend some increase of the exposures given by Mr. Whitmarsh in February. From the United States, for totality, one second with f/4.0 on black and white, and with f/2.0 for color, should yield the best visual reproduction. But in the precious seconds available make several subsequent exposures at varying larger or smaller apertures, for coronal spread or prominences, respectively. And save, if you can, a relaxed interval merely to watch the celestial show, especially through binoculars, with which totality is always an inspiring sight.

Elapsed time is the trick for motion pictures. Set your camera at minimum aperture and use the Tiffen 4X neutral filter. Most cameras have a single-frame feature, permitting one to expose evenly each second as the partially hidden sun rises. A 3-inch lens for 8-mm., and the 6-inch telephoto on 16-mm., are ample. A

Simultaneous visual monitoring and motion picture photography are here demonstrated by Louise Ferrand, using Zeiss 15 x 50 binoculars and a Bell and Howell 16-mm. camera. The latter is equipped with a standard 2.8-inch lens and a 6-inch Cine Ektar telephoto lens.

Left: On August 31, 1932, the diamond ring and the corona were captured on the same frame of a 16-mm. film by Claude Pendill.



Right: In Brazil, on May 20, 1947, Leroy G. Phelps, of the National Broadcasting Company, took this photograph of the corona as part of a lapse-time motion picture. A 2½-hour eclipse was compressed to less than a minute for television broadcasting purposes. A coelostat mirror directed the sunlight into the camera.

standby camera with standard 1-inch f/1.4 lens at infinity and full opening can be wound and ready to start running seconds prior to the moment of total eclipse.

If atmospheric visibility is unlimited, Eastman XX emulsion just may record the rapid sweep of the moon's shadow across the ground during the last few seconds before totality. To catch this impressive spectacle, the photographer must be on high ground with an unobstructed view of many miles toward the southwest, that is, in the direction opposite to the sunrise. This event would be remarkable were it to be caught by professionals with CinemaScope equipment.

When there is a greater sun-horizon separation, for observers farther to the east, sequences of totality will be most realistic with shorter focus and faster 2-, 2.8-, or 3-inch lenses wide open on 16-mm. Operation should be continuous at 16 or 24 frames per second. If a 6-inch lens is also mounted on the camera, on a turret, use it occasionally.

After totality, the break from total obscuration through the diamond ring, Baily's beads, and the slender crescent can be captured at normal taking speeds. Those fortunate enough to have a new variable-focus "zoom" lens can obtain striking effects of these events. The start would be at full focal length and diaphragm, with a slow sweep to wider angles as sunlight spreads over the earth and objects in the scene are gradually revealed. Makes of 16-mm. "zoom" lenses are the Bolex Pan Cinor, covering from medium wide angle of 20-mm. focal length to 2½ inches, and the new Zoomar, which sweeps from regular 1-inch focus to 3-inch telephoto. Both lenses are f/2.8.

In Canada, where the eclipse is high, a spare movie or still camera could be used to preserve unusual ground coloring changes during the half hour preceding totality. Expose according to meter readings. Comparison may be made with pictures taken under the same circumstances just a day earlier, or later, providing the films are processed simultaneously. Observers in Nebraska can do an analogous contrast of the normal dawn and weird eclipse daybreak colorings.

Outside the totality track, why not bring true reproduction to photographs of representative partial phases, or to a long series, without "faking" their images from another negative? The naked eye sees somewhat darkened heavens. Therefore, ahead of sun-up on eclipse day the trees, bridge, or whatever chosen subjects form foreground can be snapped against weak sky. This done, a 4.0 filter is fastened to the camera that is left stationary for a few hours while sun and moon enter the field. Again, auxiliary color equipment should record land hues as greatest obscuration passes any station.

Cinematographers just outside the track of totality ought to try filming the solar crescent as it swings swiftly around the moon from east to west at maximum eclipse. Runs at eight frames per second, for ultimate projection at sound speed of 24 frames per second, will accelerate the action desirably. Neutral-density filter 4.0 under clear skies calls for f/16 using Kodachrome, and f/32 on Super-X, with the 1/15-1/20-second shutter average.

When a camera is used with a telescope, it needs no lens if its film plane can be placed in the primary focal plane. The diaphragm rating then becomes that of the telescope (focal length divided by ob-

LETTERS

Sir:

The principal criticism in the letter from George A. Davis, Jr. (January, 1954, page 74), on the subject of star names used in the almanacs for sea and air navigation is that some of the names have been fabricated. In the course of a comprehensive revision of the provision made for astronomical navigation, a short list of stars was drawn up for use both at sea and in the air. It was considered essential to avoid Greek letters, owing to their unfamiliarity among practicing navigators and the consequent danger of mistakes; experience confirms that names are generally used in preference to numbers. In the absence of traditional names a few new ones were introduced to serve this utilitarian purpose; they are intended for navigational use only.

The named list of selected stars was agreed to by American and British navigators, and has since been adopted by other nationalities; it cannot now be changed.

G. M. CLEMENCE, director
Nautical Almanac Office
U. S. Naval Observatory
and D. H. SADLER, superintendent
H. M. Nautical Almanac Office
Royal Greenwich Observatory

Sir:

In his review of my book, **Our Neighbour Worlds (Sky and Telescope,** June, 1953), Prof. J. Allen Hynek does me less than justice in two points:

The first is the stratification in the atmosphere of Venus. Someone reading his review might assume that I give no reason for my submission that there may be both oxygen and water below the Cytherean clouds. This, however, is far from the case, for this idea is based on the magnetic properties of gases and the assumption that Venus has a strong magnetic field. In this situation, carbon dioxide, as the most strongly diamagnetic gas in existence, would exhibit a tendency to ascend, which might be further intensified by the thermal effect of absorption of obscure heat. Oxygen lies at the opposite end of the scale and shows a strong positive response to a magnetic field. It would consequently behave in the opposite way.

The second misrepresentation occurs in Professor Hynek's account of my cosmogonical conception, which he would appear to have inadvertently confused with that of Fred Hoyle. It is incorrect to say that I explain the origin of the solar system by a supernova explosion which has projected planetary material to its present distances. I assume a **nova** explosion which projected the planetary material about a thousand times as far as the present radius of the solar system. . . .*

Your readers may be impressed or not by this conception, but I do not think it should be dismissed as summarily as all that.

V. A. FIRSOFF
Carstran House, Lochearnhead
Perthshire, Scotland

July 29, 1953

*Further details of this portion of Mr. Firsoff's proposal may be found in his book. It is published in the United States by the Philosophical Library, 15 East 40 St., New York 16, N. Y. We regret the long delay in the publication of this letter of correction.—ED.

This 6-inch telescope, here operated by Richard S. Luce, is equipped with a Leica camera mounted in the eyepiece tube by a special adapter, with the camera lens removed. Aiming is done with the finder, and the right-ascension slow motion can be turned at a steady rate to keep the subject centered in the field. Photograph by John Lowell.

jective diameter), and a shutter must be provided to control exposures, unless the camera has a curtain-type shutter. A clock drive is advisable.

If projection through an eyepiece is obligatory, the exposure should be consistent with an effective focal length computed by dividing the focal length of the camera lens by the exit pupil of the telescope. The exit pupil is, in turn, equal to the objective diameter divided by the magnification obtained with the eyepiece. The camera and telescope are precisely focused for infinity, and the camera is placed as close to the eyepiece as is physically possible.

Eyepiece projection can be used also without a camera lens, and the image is focused on ground glass temporarily inserted in the focal plane. Here the required exposure time must match the focal ratio obtained by multiplying the f/number of the objective by the square of the magnification between telescope focal plane and the film. This magnification, however, depends on the setting of the eyepiece and can best be defined as the ratio of the diameters of the sun's image at the telescope focus (which equals the instrument focal length divided by 111) and that on the film plane, which can be easily measured. Advance testing with these techniques is suggested.

Rehearsal is the key to success. The eclipse comes on a Wednesday. Photographers ought to arrive in the eclipse area by the Saturday evening before. With favorable weather, this will permit three mornings of planning, site selection, and field-of-view testing as the sun ascends into eclipse position.

If bad weather makes flying imperative to see the eclipse, all photographic programs reduce to the equivalent of hand-held shooting. Moving pictures then excel, and the relatively steadier and faster medium-focus lenses are used for all phases of the event.

How to Find the Date of Easter

By H. Herbert Howe

THE AVERAGE PERSON is content to find the date of Easter for the current year by looking at a table or a calendar, and he may possibly wish that the date were less variable. Those who are mathematically or astronomically inclined, however, may be interested in knowing how to find the date themselves.

The date of Easter is defined, in the words of the law by which the Gregorian calendar was introduced into England and America in 1752: "Easter Day . . . is always the First Sunday after the Full Moon, which happens upon or next after the Twenty-first Day of March; and if the Full Moon happens upon a Sunday, Easter Day is the Sunday after."

The moon referred to in this statute is not the astronomical moon, whose motion is too complex for chronological purposes, but instead it is a fictitious mean moon, whose motion is defined by a set of rules. Space here does not permit detailed discussion of this problem, but we can gain some insight into the manner in which the calculations are carried out by considering briefly the determination of the paschal or Easter full moon under the Julian calendar, which was used in Roman Catholic countries until 1583 and in England and other Protestant countries until 1752.

If the number of the year were exactly divisible by 19, the paschal full moon fell on April 5th. For the following year, it was 11 days earlier, on March 25th. For each succeeding year, 19 days were added or 11 days subtracted, whichever would make the paschal full moon come during the interval March 21st to April 18th, inclusive. To this there was the exception that in going from a year that was 1 less than a multiple of 19 to one that was an exact multiple of 19, 12 days instead of 11 were subtracted. Thus, the full cycle of dates on which the paschal full moon could fall was completed in 19 years. Since leap year was every four years and there were seven days in a week, the full cycle after which Easter would repeat the same series of dates was $4 \times 7 \times 19$ years, or 532 years.

It is well known that under the Julian calendar the date of the vernal equinox strayed steadily from March 21st. In addition, the date of the paschal full moon strayed steadily from the date of the real full moon. Hence, when the Gregorian calendar was adopted, a more complicated system of cycles was used. The present rules originate in a book by the Jesuit astronomer, Christopher Clavius, published in 1582, which is actually the report of the commission that devised the Gregorian calendar.

While the rules of Clavius are definite enough, they are inconvenient in actual use, especially after several centuries. In 1800, the eminent mathematician, physicist, and astronomer, Karl Friedrich Gauss, published a set of formulas, equivalent to the precepts of Clavius, from which the date of Easter may be calculated for any year in a few minutes.

These formulas were reprinted in 1874 in Volume VI of Gauss' collected works, but have remained comparatively little known. I have taken Gauss' equations, put them into more systematic form, and altered them slightly to make the computations simpler. It is necessary only to make a series of divisions. For some of these we will make use of only the quotients; for some, only the remainders. In the following table, an asterisk is placed wherever we do not need to evaluate the quantity. If the division is exact, the remainder is zero; if the denominator is larger than the numerator, the quotient is zero, and the numerator is the remainder.

Let **A** be the number of the year for which Easter is desired, in the Gregorian calendar:

Numerator	Denominator	Quotient	Remainder
A	100	**B**	**b**
B	4	**C**	*
B−15	25	**D**	*
B−**D**	3	**E**	*
B+15−**C**−**E**	30	*	**f**
B+4−**C**	7	*	**g**
A	19	*	**h**
b	4	*	**j**
b	7	*	**k**
19**h**+**f**	30	*	**m**
14+**B**+**g**+2**j**+4**k**−**m**	7	*	**n**
21+**m**+**n**	31	**P**	**p**

Then Easter occurs on the **p**+1 day of the **P**+3 month of the year, with the following exceptions: When the table gives April 26th, use April 19th instead; when the table gives April 25th, use April 18th instead, provided **m** equals 28 and **h** is 11 or greater.

For example, when will Easter be in 1954? Since **A** is 1954, the first line of the table says to divide 1954 by 100; the quotient **B** is 19, and the remainder **b** is 54. Dividing **B** by 4, the quotient **C** is 4, but the remainder need not be noted. Continuing, we find that **D** is 0, **E** is 6, **f** is 24, **g** is 5, **h** is 16, **j** is 2, **k** is 5, **m** is 28, **n** is 6, **P** is 1, and **p** is 24. This gives the 25th day of the fourth month, or April 25th, but the second exception applies, and Easter is actually April 18, 1954.

It is evident that **B**, **C**, **D**, **E**, **f**, and **g** are the same for 100 years. Hence, we may shorten the computation by means of the following table, in which each column is headed with the first two digits of the year's number:

	15	16	17	18	19	20	21	22
f	22	22	23	23	24	24	24	25
14+**B**+**g**	31	32	34	36	38	39	41	36

Then, for any year from 1583 to 2299, proceed as in this example: When was Easter for 1866? 1866/100 gives 18 for **B**, and 66 for **b**. Then skip to the computation for **h**: 1866/19 has a remainder of 4; **j** is 2; **k** is 3. For **m**, use **f** as 23 from the above table; **m** is then 9. Again from the table, 14+**B**+**g** is 36, and **n** comes out 1. **P** is 1, and **p** is 0; hence, the first day of the fourth month, on April 1, 1866.

To find Easter for the Julian calendar, take **f** as 15 and **g** as 6 for all centuries, and make the rest of the computation as with the Gregorian calendar.

BOOKS AND THE SKY

SCIENTIFIC AMERICAN READER

Various authors. Simon and Schuster, New York, 1953. 626 pages. $6.00.

THE century-old **Scientific American,** which had been feeling quite poorly for some years, was rejuvenated about five years ago. Its renewed vitality is one of the show pieces of modern journalism. The principal operators in this project are editors Gerard Piel, Dennis Flanagan, and Leon Svirsky, with stimulation from some able associates, including the versatile James R. Newman and Mr. Telescope-making himself, Albert G. Ingalls. This small group has been skillful in getting the collaboration of first-class scientists, and **Scientific American** has become required reading for scientists and the science-minded public. Month after month well-illustrated technical articles in many fields are presented, with the aid of diagrams and photographs, in such fashion that the technicalities are pretty well concealed.

My assignment, however, is to review the thick book that contains an imposing selection of recent contributions to **Scientific American.** There is much to praise in the selection and in the articles themselves, several of which are written by talented science writers (such as George W. Gray and John Pfeiffer) rather than by practicing scientists.

The 57 articles are collected into 12 groups. The naming of these reviews the volume: 1. Evolution in Space; 2. Structure of the Earth; 3. Structure of Matter; 4. Atomic Energy; 5, Origin of Life; 6. Genetics; 7. The Virus; 8. Stress; 9. Animal Behavior; 10. Origin of Man; 11. The Brain and the Machine; 12. Sensation and Perception. The panorama begins with "Galaxies in Flight" and ends with "What Is Pain?" Each of the 12 parts has a two-page introduction by the editorial board.

The articles in the first group are entitled: "Galaxies in Flight," by George Gamow; "The Milky Way," by Bart J. Bok; "The Universe from Palomar," by George W. Gray; "The Dust Cloud Hypothesis," by Fred L. Whipple; and "Radio Stars," by A. C. B. Lovell.

Some of the authors have brought their stories up to the moment of printing; others have not. In the more active sciences the contributions here collected are likely to age rapidly. In five years a second **Reader** should appear, if all goes well. Some of the same topics could then be presented again. Since a static science is a petrified science, we can hope that in many of these fields revision and extension will soon be necessary.

The volume will be a comfort to the confused, who have heard much about some things but hardly understood them. But in one chapter the book will add confusion, for in Robert Marshak's brief paper on "The Energy of Stars" important revisions, based on recent laboratory work, have been made in the text but not carried over into the diagrams of the carbon cycle and the proton-proton reaction.

Readers of **Scientific American** will miss in this book the beautiful and copious illustrations that appeared with many of these articles. There are a few good line drawings, including three of galaxies, but not a halftone in the book. The typography is good, and the index adequate. The substantial price is to be expected these days, but it is probable that some thousands of students would be much tempted at half the price.

HARLOW SHAPLEY
Harvard Observatory

MEASUREMENTS OF DOUBLE STARS

G. Van Biesbroeck. University of Chicago Press, Chicago, 1954. 223 pages. $10.00.

AT THE TURN of the century, almost every active observatory in this country included the measurement of visual double stars in its program, in strong contrast with the situation today. There are many causes for this change, but the important point is that this field of work has been largely abandoned without having been exhausted.

This is illustrated by the many close binary systems, discovered by Aitken and other astronomers of the last generation, which have been so seldom observed that their orbits cannot yet be computed—even though one or more complete revolutions have elapsed since discovery.

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he has used, his known skill with the filar micrometer, and the care he has spent in planning his observing lists all contribute to the particular value of his work. It is hardly an exaggeration to say that the present volume, which contains some 10,000 measures of about 2,500 pairs from 1935 to 1951, is the outstanding single contribution to double star astronomy in recent years.

The principal novelty in these observations is Van Biesbroeck's practical demonstration of the great suitability of large reflectors for micrometer measures of close double stars. This had not been tried before. "The first trials at using the 40-inch micrometer at the Cassegrain focus of the 82-inch reflector proved so satisfactory that during recent years the great majority of the work was done with the larger instrument. Even though the pressure for time at the reflector limited its use for micrometric work to a month a year, more data were generally obtained during that short period than during the remaining months at Williams Bay on account of the superior atmospheric conditions on the mountain."

For 19 of the double stars in this volume Van Biesbroeck has computed new orbits. Perhaps the most interesting case is the system OΣ 341, with a period of 20.0 years and orbital eccentricity 0.97—a very unusual combination!

While the need for further measurements is most pressing for the close and difficult pairs like those on which the Yerkes astronomer has specialized, there is much to be done with wider pairs, up to about two seconds of arc separation. These can be very satisfactorily measured with refractors of eight to 12 inches aperture.

This opens an inviting field for the advanced amateur, to whom the measurement of double stars is particularly suited. No accessories beyond a filar micrometer are needed, and the measurements are simple to make and to reduce. The techniques are fully described in R. G. Aitken's book, **The Binary Stars** (McGraw-Hill Book Co., New York, 1935), an admirable introduction to the subject. The one other essential book is Aitken's **New General Catalogue of Double Stars within 120° of the North Pole** (Carnegie Institution of Washington, D. C., 1932).

It is encouraging to the nonprofessional astronomer that Dr. Van Biesbroeck himself began his double star work as an amateur, and that many of the outstanding observers in this field, from Sir William Herschel down through Dembowski and Burnham to the present day, were also amateurs.

J. A.

INTRODUCTION TO GEOMETRICAL AND PHYSICAL OPTICS

Joseph Morgan. McGraw-Hill Book Co., Inc., New York, 1953. 450 pages. $6.50.

WE BELIEVE that this book is the best all-around text we have seen on the subject of geometrical and physical optics at the introductory level. Usually, a textbook of this kind is written by a person interested in one of the various branches of optics, and he treats that branch with extreme thoroughness while neglecting the other aspects.

As a result, textbooks are available that are superior to Dr. Morgan's book in either geometrical optics or physical optics, but not in both fields. He has either been very much interested in all branches of optics or he has made a very definite attempt to treat all phases in proportion to their importance. This book should give the reader a clear picture of the entire field, which should be the objective of an introductory volume. There are, nevertheless, some shortcomings in Dr. Morgan's treatment of which the reader should be aware.

The usual pattern in geometrical optics is followed. A logical sign convention is adopted and clearly illustrated in the derivation of formulae. Like most writers on this subject, however, the author has made the mistake of deriving very complicated formulae for thick lenses. Specialists in the field very seldom use formulae of this type; instead they trace a paraxial ray for each lens system studied. They have devised several extremely systematic ways of tracing rays, and an explanation of these methods would make the subject much more interesting to an elementary student.

The chapter on aberrations is more extensive than is usually found in a book of this nature, but is still inadequate for a student interested in lens design. We believe the author should here do little more than try to arouse interest in this subject. This can scarcely be done by giving the long and complicated formulae of Coddington; some of Conrady's are much more interesting to the beginner.

Sky Publications

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We would like to have seen more space devoted to the eye, in the chapter on optical instruments. The treatments of the basic optical systems in a magnifier, telescope, and microscope, are more or less standard. The coverage of photometry compares favorably with that in other texts, but there is no reference to the science of color measurement. We regret, moreover, that the student is not given the beautiful concept of the "Maxwellian view," which, briefly, is:

If you wish to know the illumination at any point in an optical system, place yourself in that position and look back at the source of light. The apparent angle subtended by the source from this position determines the illumination. A searchlight beam has tremendous beam candlepower because, if one steps in the beam and looks back at the mirror, the entire mirror is seen with the same apparent brightness as the carbon arc.

The chapters on physical optics are fairly conventional. Over-all, the physical optics section is one of the better treatments available, although not the best.

Considerable attention has been given to mathematical detail; in the discussion of diffraction there are two treatments for each problem, one employing calculus and one without. This is desirable in making the book useful to persons of more varied background, but is wasteful of space which might have been used to give the reader more feeling for the subject.

Polarized light is covered in a clear and concise manner. No treatment is given of the wave surfaces in biaxial crystals. This omission is fairly common in introductory texts, but is somewhat inconsistent with the detailed attention given to the diffraction problems.

ROBERT E. HOPKINS
and M. PARKER GIVENS
Institute of Optics
University of Rochester

NEW BOOKS RECEIVED

ASTRONOMICAL PHOTOELECTRIC PHOTOMETRY, *Frank Bradshaw Wood*, editor, 1953, *American Association for the Advancement of Science*, 1515 Massachusetts Ave. N.W., Washington 5, D. C. 141 pages. $3.25 to AAAS members, $3.75 to nonmembers.

In December, 1951, a symposium on photoelectric photometry was held at Philadelphia by the American Association for the Advancement of Science, and the papers presented there are now published in expanded form. They discuss recent developments in DC, AC, and pulse-counting photometers. The bibliographies list 650 papers and books on astronomical photoelectric photometry and allied topics.

THE TRUE BOOK ABOUT THE STARS, *H. P. Wilkins*, 1953, *Frederick Muller Ltd.*, Earls Court Gardens, London S.W.5. 135 pages. 6s.

Written for children of about 12 to 15, this book gives a broad survey of astronomy in simple language. The author is the director of the lunar section of the British Astronomical Association.

MAHARAJA SAWAI JAISINGH II OF JAIPUR AND HIS OBSERVATORIES, *M. F. Soonawala*, no date given, *Jaipur Astronomical Society*, Jaipur, India. 43 pages. 2 rupees. Sold by Vani Mandir, Sawai Man Singh Highway, Jaipur, India.

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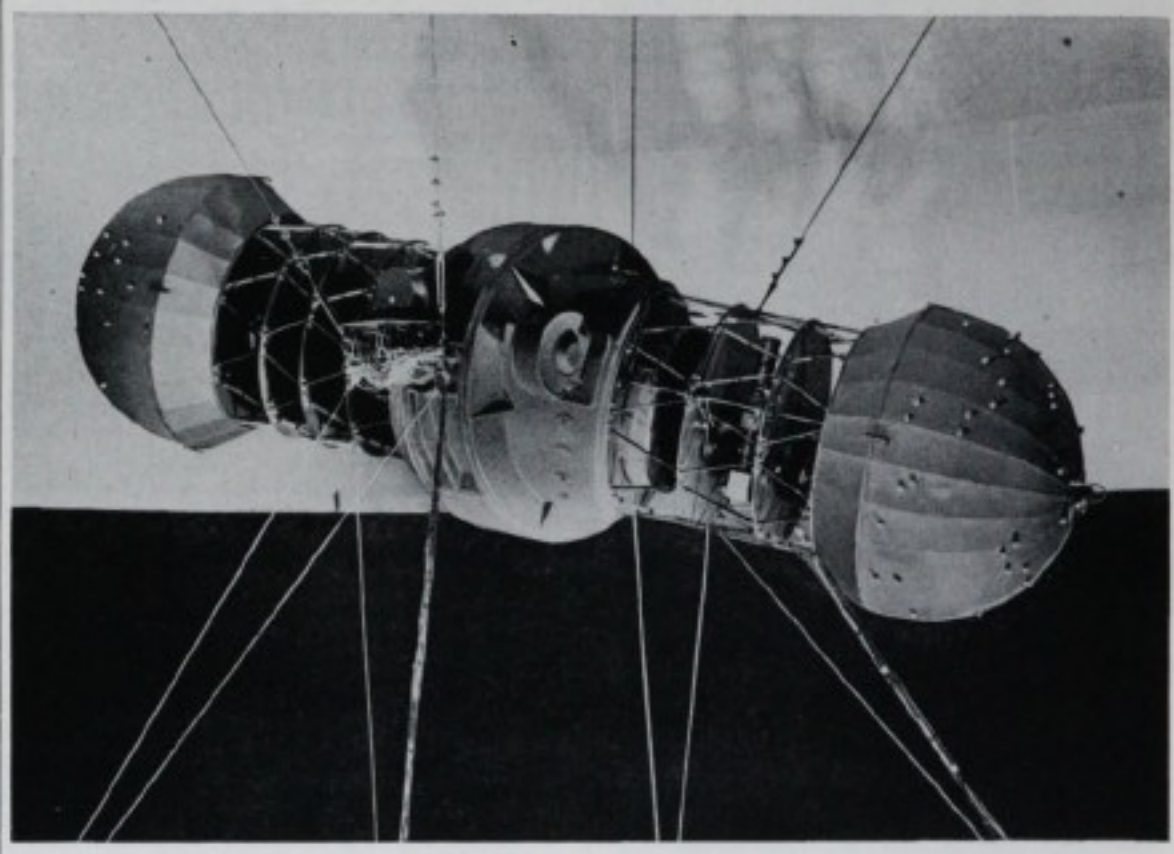

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Mr. Hubbard writes:

"Here in the Southwest, with its semi-arid climate, an open-air observatory of this type is entirely practicable. The telescope is a 3" UNITRON refractor, on a clock-driven equatorial mounting. The clock weight drives for two hours as it falls inside the 10" well casing set in a hole 4' deep. The observer's chair is of California redwood; it pivots around the pedestal, and while in the chair the observer can raise and lower it to suit the telescope position. The observatory is a 14' octagonal concrete platform with welded pipe rail and redwood seats around its perimeter. It is a busy place, as we have organized an amateur astronomy club at a nearby high school."

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for their giant masonry sundials and other astronomical instruments. Photographs and descriptions of these instruments are given in Prof. Soonawala's book, together with an outline of their astronomical principles, and historical notes.

CLIMATIC CHANGE, edited by *Harlow Shapley*, 1953, *Harvard University Press*. 318 pages. $6.00.

In May, 1952, the American Academy of Arts and Sciences sponsored a symposium at Boston on climatic changes, from the viewpoints of evidence, causes, and effects. Twenty-two scientists of varied specialties contributed papers published in this volume. The astronomical studies examine the bearing on climatic changes of fluctuations in solar radiation, stability of the sun, interstellar matter, alterations in the earth's orbit. There is also a survey of the suitability of the climates of other planets for the existence of life.

ASTROPHOTOGRAPHIE D'AMATEUR, *Jean Texereau and Gerard de Vaucouleurs*, 1954, *Editions de la Revue d'Optique Theorique et Instrumentale*, 165 Rue de Sèvres, Paris 15e. 93 pages. 800 francs.

Complete directions are given in this French book on amateur astronomical photography, for instruments ranging from small stationary cameras to equatorially mounted telescopes of long focus. There are plans for mountings and drives, information on developing and printing, and a bibliography. Thirty-five plates illustrate amateur photographs of the sun, moon, eclipses, planets, stars, nebulae, and the zodiacal light.

1954 ECLIPSE PHOTOGRAPH COMPETITION

For amateur observers in the United States and Canada, *Sky and Telescope* will conduct an eclipse photograph competition. The prizes will be $20, $10, and $5, respectively, for the three best photographs by different observers of the total solar eclipse on June 30, 1954. The pictures may be made from inside or outside the path of totality, with any combination of instruments and accessories.

An additional prize of $10 will be awarded for the best special-interest photograph of any subject related to the eclipse, such as the observing sites, equipment, groups of people, and so on.

Also, not more than five honorable mentions will be awarded.

Anyone except professional astronomers may enter the contest and may submit any number of photographs. Entries will be judged by the editorial staff of *Sky and Telescope* on the basis of combined pictorial and scientific excellence, with credit given for originality and results obtained in relation to size of equipment.

All prints submitted must be black and white, suitable for reproduction. These may be contact prints or enlargements, single photographs, pictures cut and mounted to form a sequence, series shots, series of motion picture frames, and so forth. Each picture must be accompanied by information on the equipment used, exposure data, special techniques, darkroom procedure, and other pertinent notes on the observing program.

Entries must reach the office of Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass., not later than Wednesday, July 21, 1954. It is suggested that from distant points air mail special delivery be used to meet this deadline, to avoid delay or damage in the mails. Contest entries must be clearly marked to distinguish them from other photographs and accounts of eclipse experiences that are submitted for possible publication.

The winning pictures will be published in our September issue. Other entries will be returned to the sender if adequate return postage is provided, but Sky Publishing Corporation cannot be responsible for the safe return of such entries.

NOTE: The above announcement is the same as that which was published on page 71 of the January, 1954, issue of *Sky and Telescope*.

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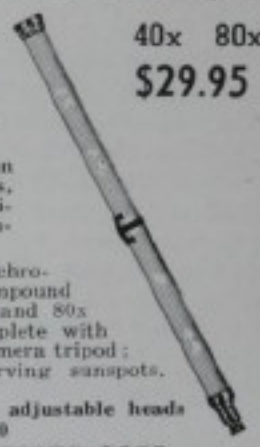

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GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

An Economical Lumber and Pipe Reflector

WHEN I made my 8-inch Newtonian reflector, machine shop and foundry equipment were not available to me, and the entire telescope was designed so that it could be constructed with simple hand tools. The instrument was made with a hammer, saw, screwdriver, hand drill, plane, file, pliers, sandpaper, coping saw, and a small bench vise. The materials used were standard items such as lumber and pipe, together with a few odds and ends from my attic and basement. The mirror blank and other optical materials were purchased from a dealer. The total cost was about $35.

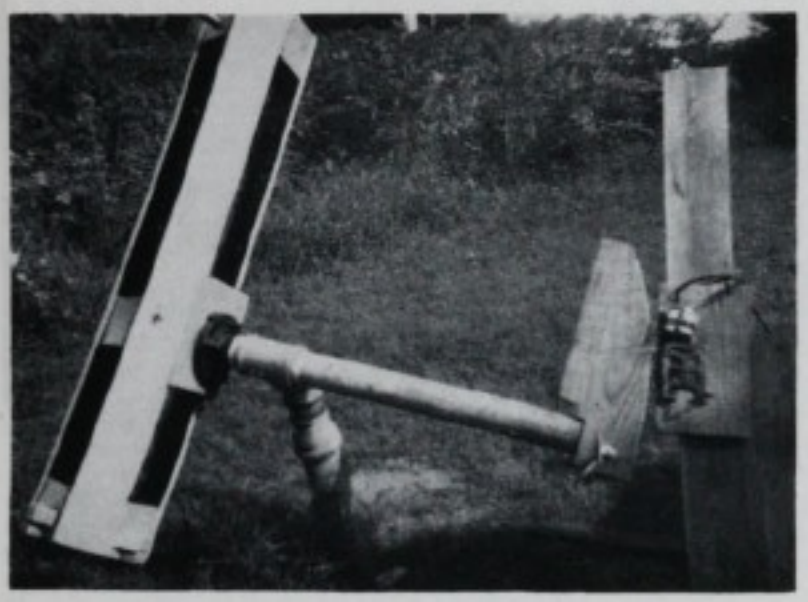
The mirror, which is aluminized, has a focal length of 59½ inches. During the grinding seven grades of abrasives were used, ranging from No. 60 carborundum to aluminum oxide. Some trouble was encountered from the mirror sticking to the pitch lap, but this was cured by using a thick mixture of jellied soap and rouge as a lubricant. Cerium oxide was found to be a much faster polishing agent than rouge.

The telescope tube is made of three pine slats separated by three hexagonal rings of the same material. The center ring, placed at the balance point of the tube, supports a heavy piece of wood through which the thread ends of four bolts protrude, and these are used to fasten the telescope to the mount.

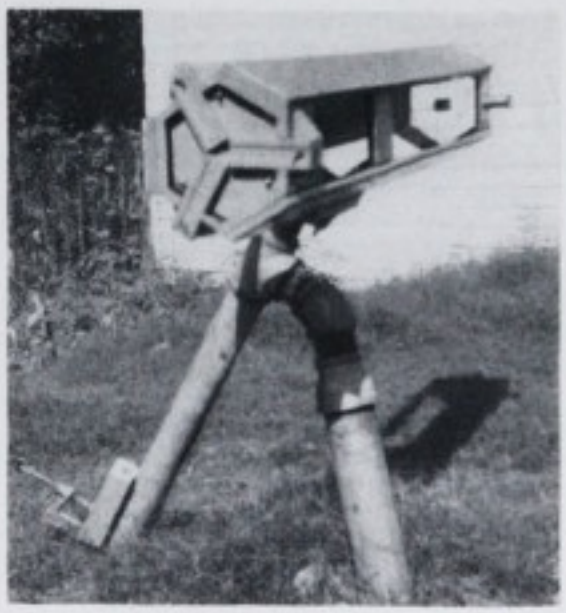
For a mirror cell I used a piece of pine ¾" thick, cut a hexagonal shape to fit the inside of the rear hexagonal ring. The mirror is held in place by wooden edge brackets and three ¼" bolts with rubber washers which grip the edge of the mirror. The cell is supported by three oak members, each drilled to receive a ¼" bolt. Wing nuts tighten these members against blocks of rubber on the tube so that the mirror may be aligned.

For the mounting, a German-type equatorial was made out of 3" pipe fittings. The parts used were a 3" companion flange, a 3" T, a 3" 45° elbow, a 3 x 4 reducer, three 3" close nipples, a 32" length of 3" pipe, and a 30" length of 4" pipe.

Both polar and declination axes are simply pipe connections lubricated with heavy grease. The telescope is fastened to the cast-iron companion flange, which has four ⅜" holes drilled through its face. A close nipple connecting the companion flange to the T serves as the



William Simpson's 6-inch reflector is driven by clockwork that turns the large toothed sector at the end of the declination axis.



This view shows the simple form of the mirror cell, and the tilt of the pier that is required to compensate for the 45° angle of the pipe fitting.

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78 mm (3 1/16")	381 mm (15").....	**21.00**
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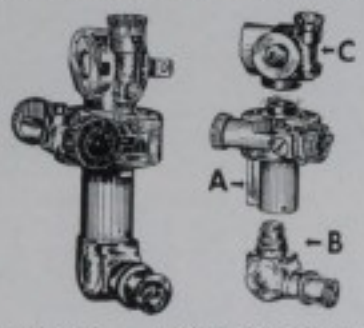

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declination axis. From the opposite side of the T extends a 32" length of pipe, which serves as a counterweight arm. The remaining side of the T is connected through a nipple to the 45° elbow and thence to the reducer, which is screwed into the 4" pipe that extends into the ground.

The latitude of Atlanta, where my telescope is set up, is 34°, so that to make the polar axis point toward the north celestial pole the 4" pipe is not vertical, but slants northward 11° from this, as can be seen in the photograph. This pipe is seated permanently in dirt and rock to a depth of 1½ feet.

The clock drive is simple but effective. The stiffness of the pipe-thread bearing surfaces of the polar axis suggested using a long lever arm to drive the telescope. A 2x4 pine plank was cut to fit snugly inside the counterweight arm, and a wooden sector of 74" radius is clamped to this plank. Along the arc of the sector is a rubber strip 15" long with 124 teeth cut in it so that each tooth describes 11.2 minutes of arc.

The drive unit is powered by a fan-cooled, 1/50 horsepower, 20-watt a. c. motor which runs a brass clockwork, whose former mainspring wheel drives the sector and with it the telescope. The drive unit is fastened to a movable stand with a small C-clamp, and this stand can be placed so that the mainspring wheel engages the rubber teeth when the telescope is pointed to any desired part of the sky.

The length of the toothed rubber strip allows tracking a star for 85 minutes. Even though the drive is still not in final form, it will keep a star close to the center of the field of a 60x eyepiece for half an hour at a time.

The performance of the telescope has been good, after a cardboard mask was inserted to reduce the aperture to 7 inches, as the edge was turned down in fine grinding. The powers generally used are 45 and 100. M13 is resolved, and the companion to Vega has been distinguished.

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ALARM CLOCK TELESCOPE DRIVE

TWO CONSIDERATIONS led to the design of the telescope drive described here. First, for a portable telescope, a mechanical clock drive has an advantage over a motor drive in that no power supply is needed. Second, the connection between clock and polar axis should be through a worm and worm gear, since in slipping the clutch to turn the telescope to another part of the sky the strain is taken by the worm bracket, and is not transmitted to the clock. Belt or spur-gear connections, such as I described in this department for December, 1948, put a severe strain on the clock gears when the clutch is slipped.

The problem in using the works of a clock was to find a shaft that would run at a suitable speed. The solution was to speed up the clock so that a 100-tooth worm gear could be used on the minute shaft. Since there are about 1,436 solar

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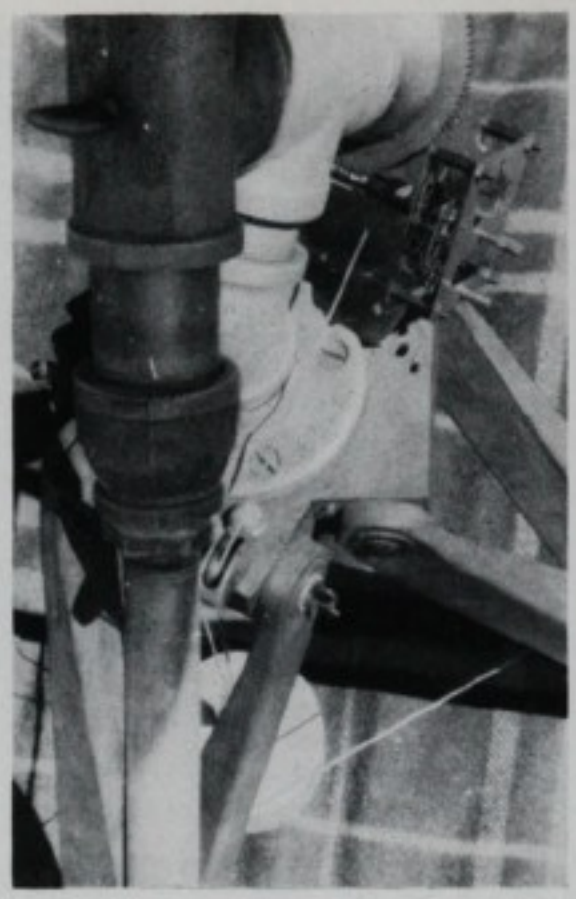

As we look down on Mr. Sweger's alarm clock drive, the weight is seen beneath the tripod, drawing the cord that runs over the pulley below the center of the picture.

minutes in a sidereal day, it was necessary for the minute shaft to make one revolution in 14.36 minutes. This was arranged by removing the balance wheel rim and gradually shortening the spokes, with frequent testing until the clock was running at the right speed. As an alternative to reducing the weight of the balance wheel, turns could have been taken from the hairspring.

On the lower end of the polar axis a collar was fastened with a set screw, and the worm gear was placed on this axis, with a cardboard disk between gear and collar. On the other side of the worm gear I put a spring disk, made from thin steel with a central hole slightly smaller than the polar axis, and with eight slots cut from the hole to within ¼" of the edge. The disk was dished by bending each of the pie-shaped pieces. On top of the tripod I made a worm bracket, pierced to take the minute shaft. With the worm in place, the minute shaft was passed through this opening and pressed into a hole in the end of the worm. Thus the clock hangs from this shaft, and is kept from rotating by a projection that presses against the worm bracket.

Since the clock spring had been broken, a weight drive was used, in which a cord, wound several times around an unthreaded part of the worm, passes over a pulley down to the weight. When the weight has run down, it is removed and the cord is wrapped on the worm again by turning the clock setting knob.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

DEEP-SKY WONDERS

THERE ARE about 150 planetary nebulae now catalogued (apart from some very faint recent discoveries), but most amateurs know only a few—although the fainter ones are often no more difficult than spirals of the same brightness. This month we give a list in order of increasing difficulty, with some comments by early and present observers.

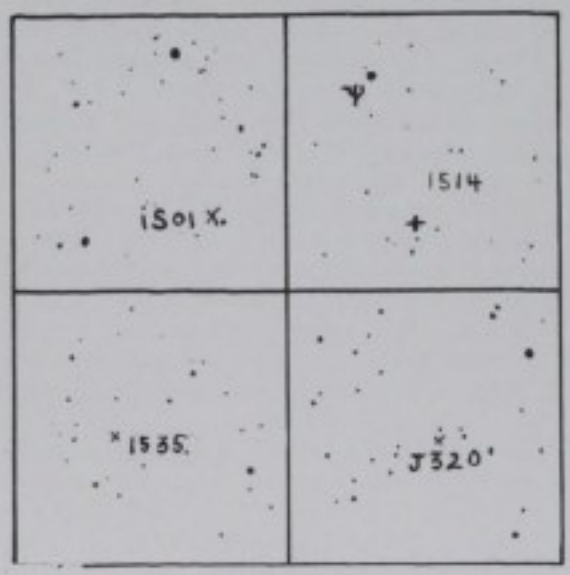
NGC 1501 is at $4^h\ 02^m.6$, $+60°\ 47'$ (1950), in Camelopardalis, 56″ by 48″ in size. Although the nebula and its central star are each catalogued as magnitude 13, the object is easier than these numbers suggest. Smyth called it bright; d'Arrest thought it conspicuous in a 4½-inch refractor; and James Corn, of Phoenix, Ariz., found it easy a few years ago. To me it is easy and bright even in small telescopes.

NGC 1514 at $4^h\ 06^m.1$, $+30°\ 38'$, in Taurus, is what is called a nebulous star; that is, the 9th-magnitude central star is much more conspicuous than the 11th-magnitude nebulosity, which is 120″ by 90″. Although Webb does not include it, its character is apparent in any telescope over a 4-inch, and the writer has seen it with a 4-inch stopped down to two inches. Corn writes that he has never been able to find it despite good Arizona skies.

In Eridanus, NGC 1535, at $4^h\ 12^m.1$, $-12°\ 52'$, is 20″ by 17″ and magnitude 9, with an 11th-magnitude central star. It is a pale, evenly illuminated disk which Smyth saw only like a star out of focus. Lassell with a very large reflector called it most extraordinary, and Corn reaches it without trouble. In the early days of spectroscopy Huggins was perplexed by its "not gaseous" spectrum, but today we know that it and a few other planetaries have practically continuous spectra. I find it easy with a 6-inch rich-field reflector.

A comparatively recent discovery by Jonckheere, J320 in Orion, is not in the NGC or earlier handbooks. Of magnitude 13 with a 13½-magnitude central star, it is at $5^h\ 02^m.7$, $+10°\ 39'$, and it is 11″ by 8″. It is fainter than the other objects listed here. I have seen it at times with a 10-inch, and it was always easy with a 16-inch. But the accompanying finder chart must be used quite carefully.

WALTER SCOTT HOUSTON



The scale of these finder charts is one centimeter to one degree. South is at the top, east to the right.

SUNSPOT NUMBERS

From Zurich, Dr. M. Waldmeier reports that no sunspots were observed during January. The American sunspot numbers, compiled by the American Association of Variable Star Observers, are all zero, except for January 11th.

On that date, two spots were observed by C. Macris, at Athens, Greece, but four other observers saw no spots. At Mount Wilson Observatory, whose solar observations are not included in the American sunspot numbers, two spots were also seen on the 11th.

MOON PHASES AND DISTANCE

New moon	April	3, 12:25
First quarter	April	10, 5:05
Full moon	April	18, 5:48
Last quarter	April	26, 4:57
New moon	May	2, 20:22

			Distance	Diameter
	April			
Perigee	3,	20^h	221,900 mi.	33′ 28″
Apogee	17,	20^h	252,500 mi.	29′ 24″
	May			
Perigee	2,	7^h	222,200 mi.	33′ 24″

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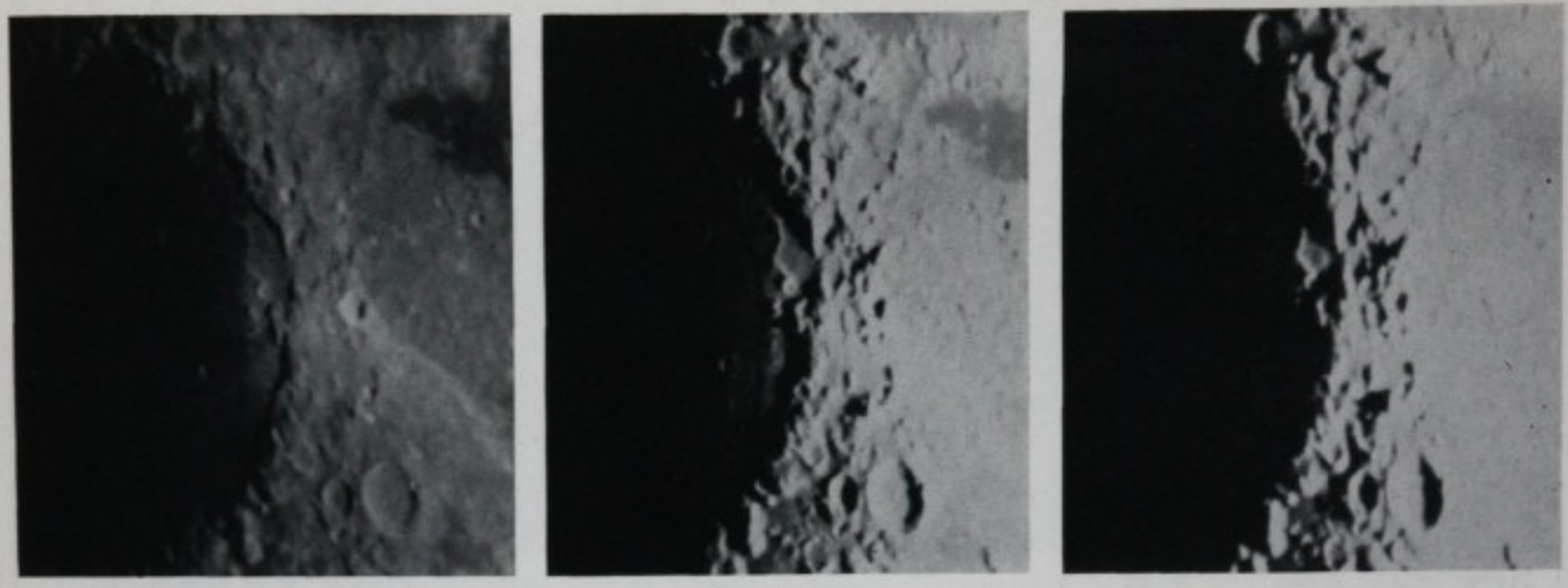

These photographs of the Mare Crisium region were taken at the Griffith Observatory in Los Angeles for the express purpose of checking on the existence of the bridge. The 12-inch refractor was used this January, on the 21st at 6:25, the 22nd at 6:26, and the 22nd at 12:47, UT, respectively. The exposures were four seconds, on Super Panchro Press type-B film, with a CG3385 filter. South is at the top. Photographs by Paul E. Roques.

Is There a Bridge on the Moon?

HOW A LUNAR FORMATION appears depends critically on the location of the moon's terminator relative to it. In many cases it is only during a few hours of each month that the illumination is suitable for determining the nature of a lunar feature. This explains why the object described below did not earlier attract general attention, and why the discoverer's interpretation will not be easy to test.

On July 29, 1953, the late John J. O'Neill, science editor of the New York **Herald Tribune,** was examining the eastern rim of Mare Crisium, where this adjoins Palus Somnii. This region was then grazingly illuminated by a setting sun. Using a 4-inch refractor at 90x, Mr. O'Neill saw an illuminated area on the floor of Mare Crisium, adjoining the eastern rampart, and this he interpreted as sunlight shining through a great natural bridge in the east wall. On the night before, he had seen two separated promontories in the location of the bridge. These observations are reported in the October, 1953, issue of **The Strolling Astronomer,** published by the Association of Lunar and Planetary Observers.

So far, the only confirmation of the existence of the bridge comes from press reports, which assert that it was seen in England by H. P. Wilkins in August, and by Patrick Moore in September. These observations cannot be evaluated until the details of what the observers saw become available.

There is on the other hand strong evidence against the existence of the bridge. With the 12-inch refractor of the Griffith Observatory, Paul Roques observed the region visually and photographically on September 26, 1953, when the lighting was identical with that at Mr. O'Neill's observation. He found no bridge, but concluded that there is merely a gap in the ridges bounding the eastern part of Mare Crisium.

Through the courtesy of Dr. Dinsmore Alter, director of the Griffith Observatory, several later photographs by Mr. Roques have been made available for reproduction here. The three pictures show the region under progressively lower illumination by the sun. The third was taken when the sun's colongitude was 126°.8, very nearly the same as the 127°.2 for the July 29th observation.

The first of these photographs shows the two promontories seen by Mr. O'Neill on July 28th. This view may be compared with the description in Edmund Neison's classic, **The Moon,** page 149, London, 1876: "Near the centre of the east border it is broken by a fine pass, bordered on each side by two lofty points that have been named **Promontorium Olivium** and **Promontorium Lavinium,** on each of which is situated a craterlet."

The fan-shaped patch of light at the eastern edge of Mare Crisium in the third photograph is evidently the same appearance as that seen by Mr. O'Neill. However, it seems easily explained by sunlight coming through the pass and over the sloping shoulders of the promontories, falling on rising land to the westward.

In my opinion, while the existence of the bridge is quite unlikely, this area deserves careful study by observers. The suitable current times for observation are, according to a list prepared by Walter H. Haas, editor of **The Strolling Astronomer:**

1954, UT	313°	127°
April	6d 23h	21d 6h
May	6 11	28 18
June	4 23	19 5

The column headed 127° gives the times when the illumination by the setting sun will match that of the O'Neill observation, and the times labeled 313° are when the rising sun has the corresponding elevation.

Mr. Haas comments: "Of course, observations can and should be made for several hours on either side of the times given. In the United States the best opportunities will be very soon after sunset on April 6, local civil time date, and soon before midnight by local civil time on April 20 and June 18." J. A.

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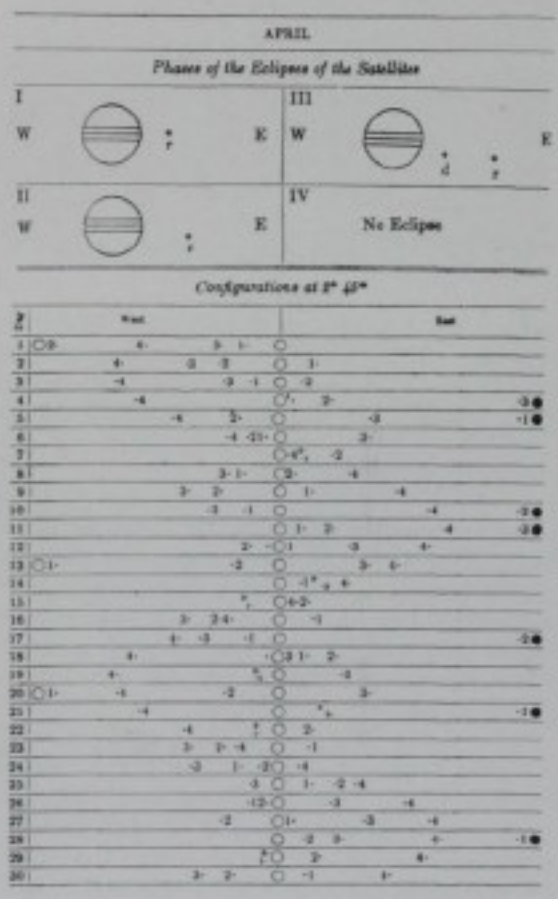
JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, **d** is the point of disappearance of the satellite in Jupiter's shadow; **r** is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given; subtract one day from the date when converting to times in the United States. The motion of each satellite is from the dot to the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the **American Ephemeris and Nautical Almanac.**



OCCULTATION PREDICTIONS

April 9-10 **Delta Geminorum** 3.5, 7:17.4 +22-04.1, 7, Im: **A** 2:04.4 −2.3 +0.5 53; **B** 2:05.1 ... ... 41; **C** 1:55.3 −1.9 −0.5 76; **D** 1:49.6 −2.2 +0.1 64; **E** 1:28.1 −2.0 −0.8 95; **F** 1:28.0 −1.7 −2.2 132. Em: **A** 2:38.7 +0.8 −3.9 353; **B** 2:26.8 ... ... 3; **C** 2:51.4 0.0 −2.8 331; **D** 2:37.6 +0.1 −3.2 341; **E** 2:42.4 −0.9 −2.2 311; **F** 2:48.1 −1.9 −1.0 275.

April 12-13 **Pi Leonis** 4.9, 9:57.8 +8-15.9, 10, Im: **E** 7:51.8 −0.3 −1.6 99; **F** 8:04.2 −0.3 −1.7 118; **H** 7:41.7 −0.8 −2.2 135; **I** 7:11.8 −1.0 −1.8 118.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

APRIL METEORS

The annual Lyrid meteor shower will be at maximum on April 21st, although some of the characteristically swift Lyrids may be seen five days before and after that date. Under good conditions, 10 meteors per hour may be expected, radiating from a point southwest of Vega. The moon, in Scorpius, will interfere this year, three days past the full phase. E. O.

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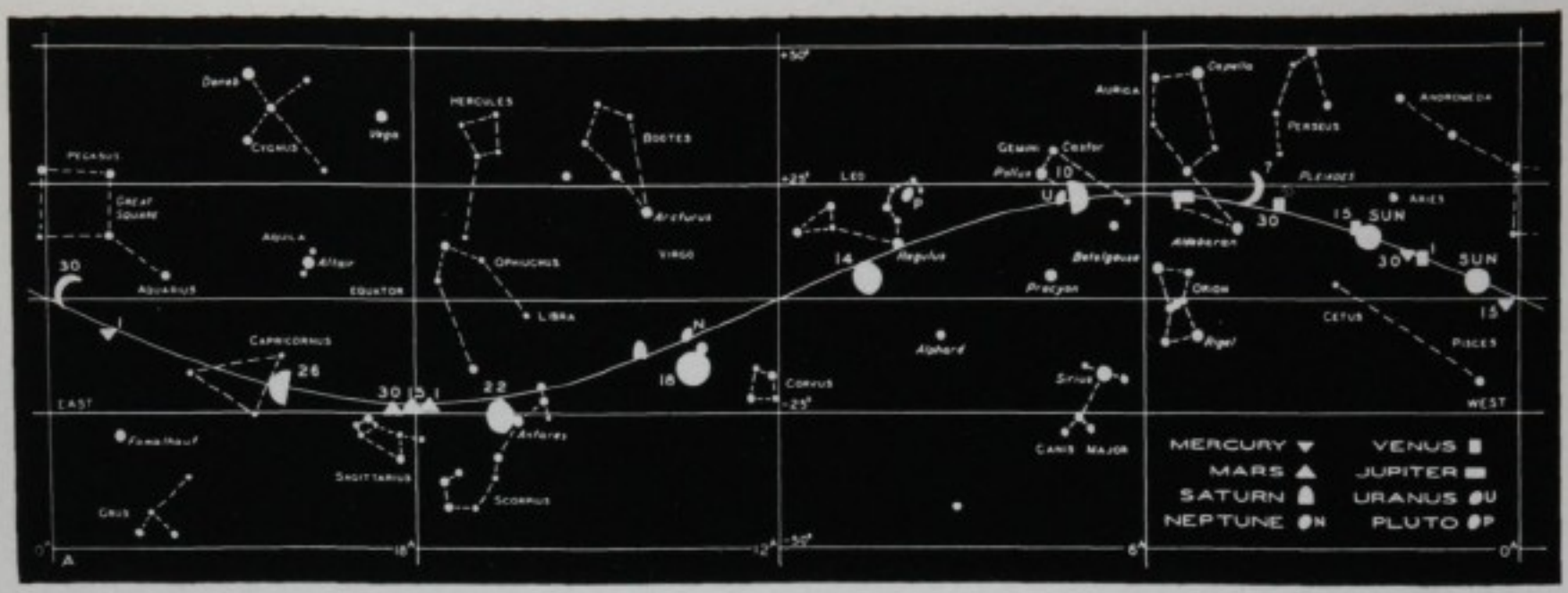

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury, in the morning sky all month, will be poorly placed for observers in northern latitudes. During the first days of April, Mercury can be seen with difficulty as a +0.4-magnitude object rising three quarters of an hour before the sun.

Venus is brilliant low in the west after sunset, in mid-April setting as evening twilight ends. Viewed in a telescope, Venus presents a nearly full disk, 11″ in diameter on the 15th.

Mars continues to grow brighter as it approaches opposition in June. On April 15th it is magnitude −0.2, rising in the southeast at midnight. It is on the meridian only 4½ hours later, due to its southerly declination, −24°, in Sagittarius. Telescopically, the disk increases from 10″ to 13″ in diameter during the month.

Jupiter, visible only during evening hours, is moving eastward in the horns of Taurus, appearing as bright as Sirius, magnitude −1.6, in mid-month. The disk of Jupiter is 35″ in equatorial diameter, a fine telescopic object.

Saturn reaches opposition on April 26th, as it crosses the boundary from Libra into Virgo. Its distance is 819 million miles from the earth; its stellar magnitude is +0.4 at opposition. The ring system, inclined 17°.6 to the line of sight, will measure 42″.6 in length and 12″.9 in breadth on the 26th, with the diameter of the planetary disk 17″.

Uranus passes eastern quadrature with the sun on April 9th, and may be viewed only before midnight. Looking like a 6th-magnitude star, this distant planet may be found 1½° east of Delta Geminorum.

Neptune, also in opposition this month, on the 15th, is 2,726 million miles from the earth. It is in eastern Virgo, at 13^h 34^m.1, −7° 56′ (1954), on the 15th, and it is of magnitude 7.7. E. O.

MINIMA OF ALGOL

April 2, 1:38; 4, 22:28; 7, 19:17; 10, 16:16; 13, 12:56; 16, 9:45; 19, 6:34; 22, 3:23; 25, 0:12; 27, 21:00; 30, 17:49. May 3, 14:38; 6, 11:27.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

QUESTION AND ANSWER

Q. Is more than half of the whole starry sky visible to an observer on the earth at any moment? If so, how much more? — J. M. Campbell, Box 1225, Coolidge, Ariz.

A. Because of the refraction of light in the earth's atmosphere, all stars are seen slightly raised above their true places, and thus a star 34 minutes of arc below the true horizon would just be visible. Hence the sky area visible to an observer at sea level is one per cent more than a hemisphere.

There is an additional gain if the observer is above sea level, owing to the dip of the horizon. This gives a further one per cent if the observer's altitude is 1,000 feet. — J. A.

VARIABLE STAR MAXIMA

April 3, W Andromedae, 021143a, 7.5; 7, R Leonis, 094211, 5.9; 7, V Coronae Borealis, 154639, 7.4; 12, R Indi, **22**2867, 8.0; 15, U Ceti, 022813, 7.5; 15, S Canis Minoris, 072708, 7.5; 17, RS Herculis, 171723, 8.0; 18, R Pegasi, 230110, 7.9; 25, R Cancri, 081112, 6.8. May 2, RT Hydrae, 082405, 7.6.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

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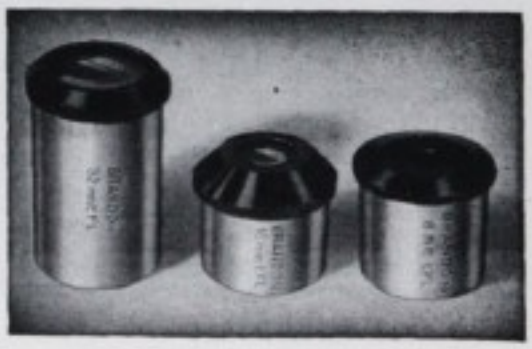

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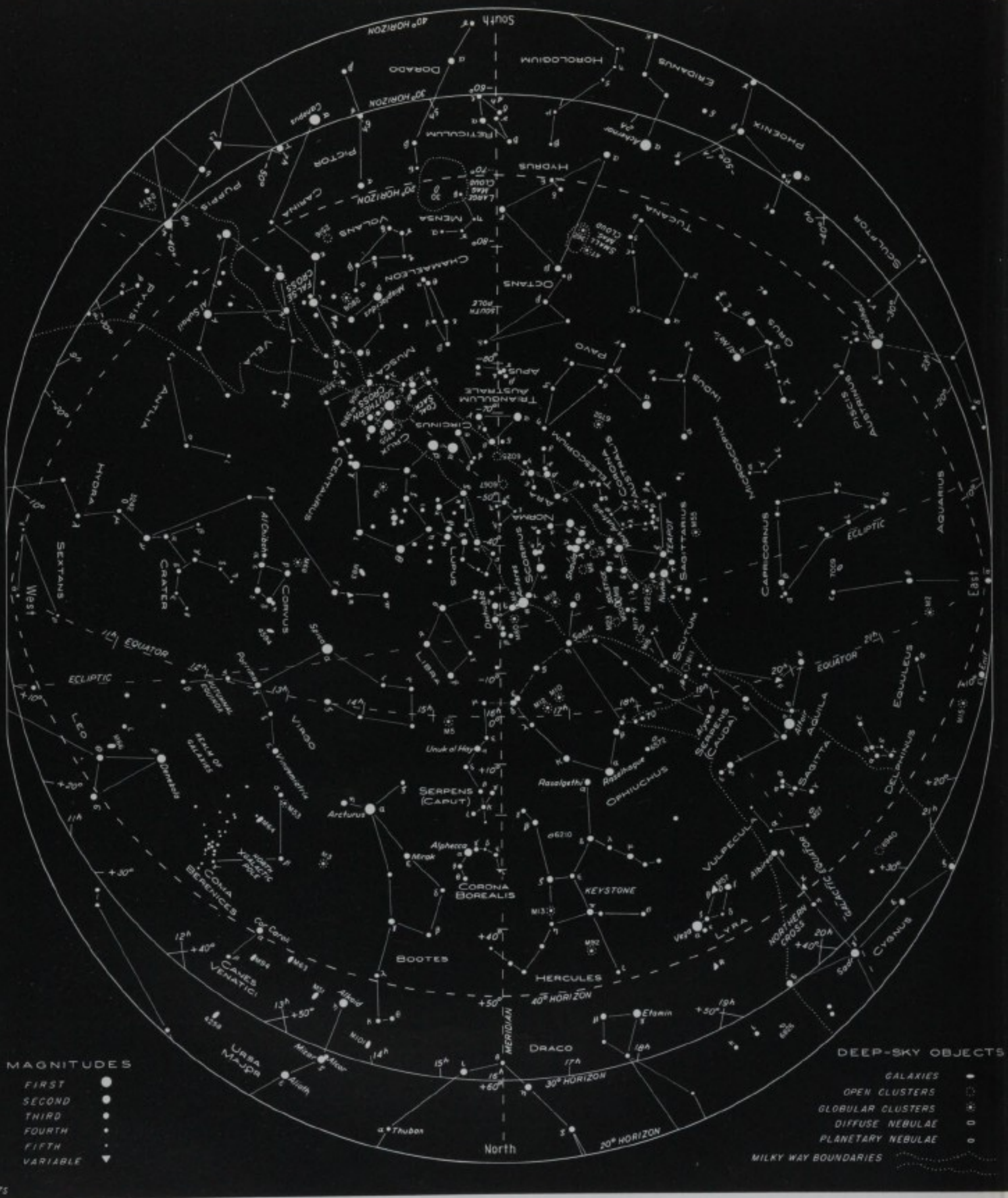
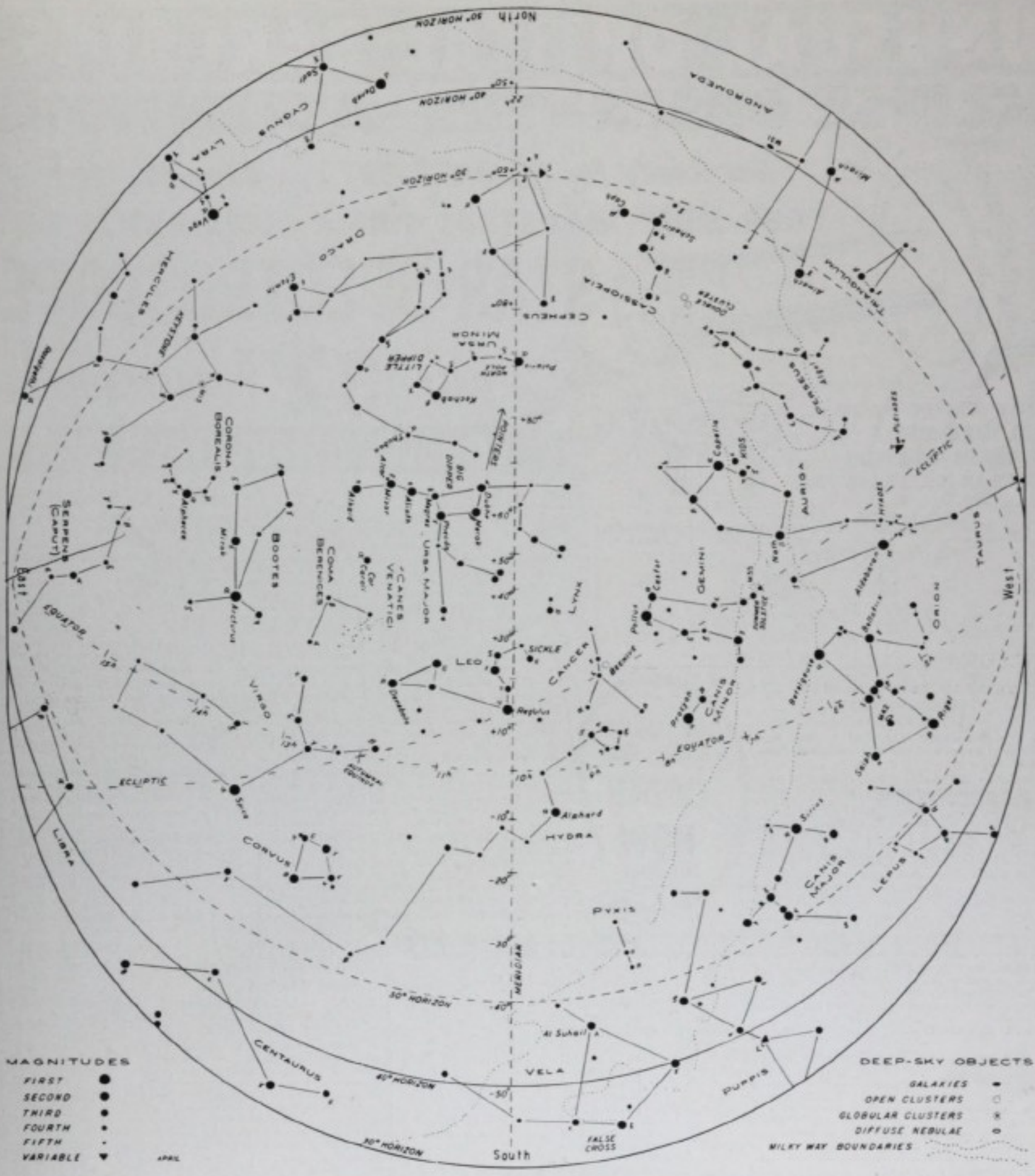


SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively; also, at 7 p.m. and 6 p.m. on August 7th and 23rd. For other times, add or subtract ½ hour per week. When facing south, hold "South" at the bottom; turn the chart correspondingly for other directions. Celestial hour circles and parallels are represented as parts of circles.



The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of April, respectively.

STARS FOR APRIL

LEO, one of the most striking of the zodiacal constellations, stands high in the southern sky in the evenings of April. The white 1st-magnitude Regulus lies at the end of the handle of a sickle-shaped group of stars, which comprise the head and forequarters of the recumbent lion. The 2nd-magnitude star Denebola marks the tail of this traditional figure.

Within the curve of the Sickle lies the radiant point of the historic Leonid meteors, which appear about November 14th of each year. In 1799, 1833, and 1866, the Leonid shower was extraordinarily rich, a literal rain of swiftly moving bluish meteors, too numerous to count. Since then, the shower at 33-year intervals has been well marked but not exceptional. The orbit of the meteor stream has been displaced by planetary attraction so the earth no longer passes through the center of the swarm, and only a few Leonids are seen each November.

At this time of year, we can trace the entire length of Hydra, the Water Monster, a straggling constellation of mostly faint stars, which extends from the southeastern horizon nearly to Procyon in the southwest. Tracing an imaginary line from Gamma Leonis through Regulus and twice as far again leads to Alphard, an orange 2nd-magnitude star in the heart of Hydra. The head of the monster can be readily located as a compact pentagon of stars about midway between Alphard and Pollux, south of the dim Y-shaped figure of Cancer.

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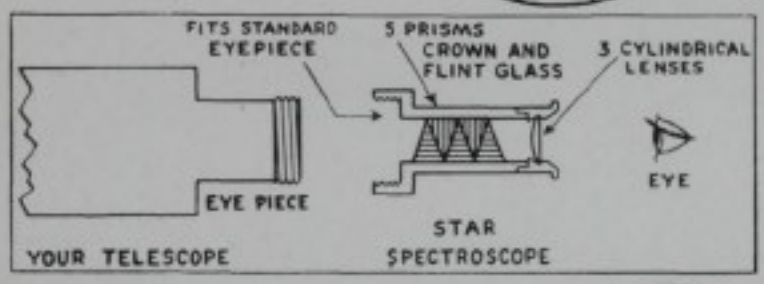

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Are you planning now to observe the total eclipse in June? Will your equipment include everything you need for this great astronomical event? We can supply many needed parts, filters, and the like, all described in our catalog, but most of all you should have our Star Spectroscope to view the **flash spectrum.**

The flash spectrum occurs just when the moon has covered every bit of the sun's brilliant photosphere. Then the normally dark absorption-line spectrum of the sun changes abruptly and magically to the bright-line spectrum of the chromosphere and the reversing layer. This is the instant of the beginning of totality. Then you watch the bright lines become fewer and fewer as the moon moves on until it has covered the whole chromosphere . . . but that is not all. The same thrilling observation can be made at the end of totality, on the other side of the sun. There the flash spectrum appears first from the top of the chromosphere, gradually gets brighter and more complex, and at the end of totality suddenly reverses to the ordinary solar spectrum. The height of the sun's chromosphere can be estimated from the time during which the flash spectrum is visible.

The STAR SPECTROSCOPE is a must if you are going to observe this marvelous sequence of events. Attach it to your telescope eyepiece a few minutes before totality. The crescent of the sun acts as its own slit as the moon makes it narrower and fainter. The flash spectrum, as shown in astronomical pictures, needs no slit. The appearance of the bright lines of the flash spectrum in exactly the same positions as the dark lines of the sun's ordinary spectrum demonstrates Kirchhoff's laws of the formation of spectra.

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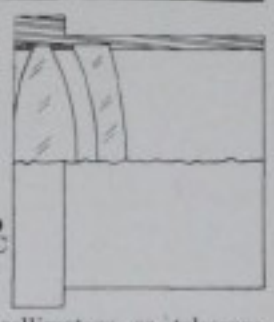

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